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Vol. 11 July, 1956 No. 1

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FORMER ISSUES OF GAZETTE

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Volume 1, Number 1.
Volume 2, Numbers 1, 2 and 3.
Volume 3, Numbers 1 and 2.
Volume 4, Numbers 1, 2, 3 and 4.
Volume 5, Numbers 1, 2 and 3.
Volume 6, Numbers 1, 2 and 3.
Volume 7, Numbers 1, 2, 3 and 4.

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The Papua and New Guinea
Agricultural Journal

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COFFEE IN THE HIGHLANDS

J. W. BARRIE *

THE high prices that have been obtained for good quality arabica coffee over the last few years have greatly stimulated Territory interest in this plantation crop. This article applies specifically to coffee cultivation in the Highlands of New Guinea and is intended to meet, as far as possible, the immediate needs of intending coffee producers in this region. It is not intended to discuss in detail aspects of a highly technical nature but to concentrate more on the agronomic fundamentals of correct plantation establishment and management for the successful owner-manager.

It is fairly evident that coffee seed was first introduced to the Highlands by the Lutheran Missionaries some years before the war. The seed was introduced from the Finschhafen area and was the green-tipped bourbon arabica coffee. Some of the earliest Highlands planting are still surviving at the Lutheran Mission station at Asaloka some miles from Goroka. These trees have grown to approximately twenty feet in height and have continued to thrive and crop well despite the fact that they were entirely neglected during the war years and for some time after. They are typical green-tipped bourbon arabica coffee.

Since the introduction first of bourbon coffee to the Highlands various other species and varieties have been introduced. Blue Mountain Jamaican arabica coffee introduced from Wau was planted at Aiyura in 1937. Small quantities of robusta seed were introduced by the Lutheran Mission. Later still a number of other arabica varieties were introduced and planted at Aiyura for observational and experimental purposes.

The Botany of the Coffee Plant.—

The coffee plant belongs to the Genus *Coffea* and the Family *Rubiaceae.* Although there is some doubt among botanists regarding the classification of the Genus *Coffea,* the more recent publications list four species of economic importance. In order of world importance these are :—

1. *Coffea arabica* Linn.
2. *Coffea canephora* Pierre ex Froehner.
3. *Coffea liberica* Bull ex Hiern.
4. *Coffea excelsa* A. Chev.

Coffea robusta is included as a form or variety of *Coffea canephora.*

As *Coffea arabica* is the only species of economic importance in the Highlands it is not proposed to deal with the remaining species in any further detail.

The species *arabica* is indigenous in Abyssinia and possibly part of Arabia. In Abyssinia, it is found mainly in the southern mountains between latitudes 7 and 9 degrees north, among fringing forest growths and along the shaded banis of streams at altitudes from 4,500 to 6,500 feet.

* District Agricultural Officer, Eastern Highlands, Department of Agriculture, Stock and Fisheries, Administration of Papua and New Guinea.

Botanically the plant is a glabrous, glassy leaved shrub or tree. The flowers are white or creamy and are borne in clusters at the nodes on new lateral wood. Self-pollination is usual although cross-pollination may be effected by wind or insects.

The fruit which resembles a cherry, is a two-seeded drupe, normally containing one seed in each locus.

It is proposed to discuss the agronomic aspects of coffee cultivation in the Highlands under the following headings :—

1. Varieties.
2. Soils and Climate.
3. Land Preparation.
4. Plantation Management.
5. Pests and Diseases.
6. Harvesting.
7. Processing.
8. Marketing.

Varieties.

Almost all of the arabica coffee plantings in the Highlands are derived from seed introduced to Aiyura in 1937. The bulk of the plantings consist of the two botanical varieties ;

(a) *Coffea arabica* L. var. *typica,* usually referred to as " typica " coffee.

(b) *Coffea arabica* L. var. *bourbon,* usually referred to as " bourbon " coffee.

The proportion of planting are approximately 80 per cent. typica and 20 per cent. bourbon.

Odd plants are noticed of several other varieties or types of the arabica species. Among these is the " maragogipe " coffee with the large, bold bean but rather poor yield, plus " mocha " coffee, and several other types of uncertain designation.

Of the two varieties, bourbon and typica, the bourbon coffee appears to be the more suitable for the Highlands. Although the cherry size is slightly smaller than that of typica, the bourbon trees appear to be the higher yielding variety.

The two varieties are readily recognized in that the new leaf growth of typica coffee is a light bronze or brownish colour, and a light greenish colour in the bourbon variety.

Typically the main branches of the bourbon variety grow stiffly upwards at first at an angle of 45 degrees from the trunk, but later curve outwards and downwards under the weight of the crop. The internodes are more closely spaced on the laterals, thus the clusters of fruit are closer and more numerous on the bearing branches. The leaves of the bourbon coffee are generally broader than those of the typica variety. With regard to crop maturity time, it is noticeable that the cherry on typica trees matures more quickly than on bourbon coffee trees.

Apart from its apparent higher yielding capacity, bourbon coffee is preferred because of its obviously more vigorous and sturdier growth, and its greater tolerance under drier and unshaded conditions in the Highlands. When grown under little or no shade, particularly in the more marginal rainfall areas, typica coffee is prone to develop a bunchy and compact shape, and to crop heavily and prematurely. This applies more particularly to the Eastern Highlands where more severe and protracted dry seasons may be expected. Premature heavy cropping usually predisposes the coffee tree to " die-back ". Bourbon trees, however, do not appear to be as adversely affected by premature heavy cropping, and do not suffer from " die-back " to the same degree as neighbouring typica trees.

Overseas experience has indicated that bourbon coffee requires certain environmental factors for optimum growth. In Brazil, bourbon coffee is now much sought after by planters, because of its higher yields and reputed high liquoring qualities. In East Africa, however, bourbon coffee is said to be weaker in stamina than the variety typica, although it is recognized as a coffee of fine quality and liquor. Judging from observations in the Highlands the writer would venture to say that the Highlands environment does seem conducive to optimum bourbon coffee growth.

In the lower rainfall areas of the Highlands it may be that some of the more compact, and reputedly drought-resistant arabica varieties may prove to be more suitable than either typica or bourbon.

Soils and Climate.

Arabica coffee is fairly tolerant to a wide range of soil and climatic conditions, but prefers a fertile, friable, well-drained soil, and a cool temperate climate free of frost, without strong winds, and with a well-distributed annual rainfall of not less than 75 inches. Overseas authorities maintain that arabica coffee prefers altitudes between 4,000 to 7,000 feet. However, New Guinea experience has shown that arabica coffee can be grown quite sucessfully at 3,000 feet and that above 6,500 feet the general growth rate and vigour of the plant is rather less than at the more optimum altitudes.

Coffee Soils of the Highlands.—

Generally the coffee soils of the Highlands are very heteorogeneous in that they vary greatly in apparent fertility, texture, depth and ease of drainage. Even at this early stage of development it is obvious that some of the Highlands soils are good coffee soils and others are only fair, or unsuitable for coffee culture. A coffee soil should be slightly acid, pH values between pH4.5-pH6.0 are considered optimum. Most of the Highlands soils would be within this pH range.

Good drainage is a primary prerequisite in determining the suitability of a soil for coffee growing. It is becoming increasingly evident in the Highlands in soils where drainage is impeded, due perhaps to the presence of laterite layers, or impervious clay subsoils underlying shallow topsoils, that such soils are not very suitable for coffee.

With respect to fertility, most of the coffee soils appear to be average to good. Variations appear in apparent fertility in all areas and over most plantations, but very few of the soils could be considered as too infertile for coffee growing. Other soil factors being conducive to successful coffee culture, apparent low fertility may be remedied by fertilizing.

Apart from drainage and fertility, the depth of friable topsoil and permeable subsoil are also major factors in deciding coffee soil suitability. In general, coffee has a short taproot, penetrating the soil for a distance of usually two to three feet. In addition to this there is the network of fine feeding roots close to the surface, plus the moisture-seeking roots which grow downwards in the soil under the surface-feeding roots. It is axiomatic that a deep, friable, free-draining soil will be more conducive to the maximum development of the root system than shallower and not so well-drained soils. The soil depth and coffee growth response relationship is well illustrated in any area of coffee plantings where the plantings extend from sloping land on to fairly level land. It can be seen that almost without exception, the coffee trees improve in growth and vigour the closer they are to the bottom or the top of the slope. On undulating areas of coffee plantings, growth patterns soon become evident with the bigger and more vigorous trees being in the lower-lying and more level areas. The obviously more vigorous growth observed with plantings is almost correlated with the greater depth of topsoil and a higher soil moisture content, especially during the dry season.

It is suggested that, where slope plantings are made, it is most important that the plantings be on the contour, and that the area be adequately and permanently mulched to conserve soil and moisture. The mulching should also be across the slope rather than up and down the slope.

In the Highlands the deep, friable free-draining, red-loam soils of the upper Asaro Valley are proving to be excellent coffee soils.

On the grassland areas, other than areas of Giant Kangaroo Grass, *Themeda gigantea,* the soils are shallower and generally heavier in texture. The coffee growth response on these soils has not been as promising as on the friable, red-loam soils. Drainage is of paramount importance on the grassland soils, as many of the soils overlay impervious clay subsoils. Lateritic formations, impeding drainage are also more common in the shallower grassland soils.

The darkly coloured, semi-peat soils, characterized by a dense growth of *Phragmites* sp. and *Saccharum* sp. (pit-pit) are proving to be very good coffee soils. However, it is stressed that these soils first require extensive draining before being suitable for successful coffee planting.

Throughout the Highlands, several endemic grass species are reasonably reliable

indicators of soil types, particularly with regard to depth and drainage. It is noticeable particularly where the grass species, *Arundinella furya,* and to a lesser extent, *Capillepidium parviflora,* is the dominant species in the grass flora, that the soils are shallow or poorly drained. These soils are proving unsuitable for coffee culture. However, where *Themeda gigantea* is the dominant species, the soils are generally deep, fertile and free-draining, and very suitable for coffee.

Climate.—

The Highlands climate is on the whole regarded as favourable for coffee production.

It does appear that the dry season, particularly in parts of the Eastern Highlands may be more protracted than experienced in other world coffee producing centres. The general concensus of opinon in most of the successful coffee growing regions of the world, is that the rainfall be no less than 70 inches per annum and fairly evenly distributed throughout the year, with a few months, two to three, of drier weather, but not without occasional showers.

Throughout the Highlands coffee districts, the rainfall ranges from approximately 55 inches in the drier grassland areas to over 100 inches per annum in parts of the Wahgi Valley. In the drier areas it is important that the deficiency in annual rainfall be compensated for by irrigation, mulching, adequate permanent shade, and other moisture conserving practices.

Temperature control is very necessary for successful coffee production. Temperatures that are above the optimum for coffee induce a rapid early growth, premature cropping and exhaustion of the young plant —all of which predisposes the plant to " dieback ". Overseas authorities contend that the average temperatures in arabica coffee producing regions are 55 degrees F. minimum, 80 degrees F. maximum and a mean of 70 degrees F. In the Highlands of New Guinea it is considered that optimum temperatures can be regulated by mulching to lower the soil temperatures and the judicious control of shade to mitigate air temperatures.

When the temperatures are too cold, arabica coffee has little vigour. It grows slowly and is stunted. Cold winds and light frosts are liable to blacken and distort the young growing tips. In the Highlands the majority of coffee plantings are between the 4,500 and 6,000 feet contours. Some Native plantings are between 7,000 and 8,000 altitude. Although the plants at the higher altitudes appear healthy, they are slow-growing and lack vigour compared with the lower altitude plantings. It is also evident that the crop matures more slowly—about ten months as compared with six to nine months up to the 6,000 feet level.

Frosts are rarely recorded as low as 7,000 feet.

Land Preparation.

When preparing land for coffee planting, it should be borne in mind that although the soil and climatic conditions are favourable, there are other local factors which if intelligently recognized may considerably enhance the future potential and ease of management of the plantation.

Firstly it is an asset if the land be flat or only gently sloping. A relatively flat area of land will greatly facilitate irrigation, drainage, and other cultural operations.

The direction of the prevailing winds, especially during the drier months, should be noted. The importance of protecting coffee plantings from winds cannot be stressed too greatly. Every effort should be made to utilize natural land or vegetative wind barriers, or if adequate, to plant windbreaks. The use and importance of windbreaks will be discussed in more detail later.

A plentiful and permanent supply of clean water is essential, both for processing operations and for domestic use. The lie of the land may determine if the water can be obtained by gravitational or mechanical means. The possibilities of utilizing any available waterways for the generation of electric power should not be overlooked.

Clearing.—

With few exceptions, the majority of coffee plantings in the Highlands are situated on land which had as its natural cover a dense grass flora. The clearing of the grassland is in most cases a fairly simple operation.

In grasslands where the grasses are not more than about waist height, areas can be quickly cut and cleared by gangs of labourers using bush knives. In some cases, burning of the grasslands is practised. After the initial clearing, either by cutting or burning, the cleared area may be quickly cultivated and cleared of the grass roots and crowns either by mechanical cultivation with disc ploughs, or by large Native labour gangs using spades and shovels. It is recommended that the work of clearing and cultivating the land in preparation for planting should be commenced at least six months prior to planting. This means that the land should be completely cleared and prepared by the end of the dry season.

In some cases, particularly on lower-lying areas of deep, permanently moist soils, dense stands of tall-growing, vigorous *Saccharum* and *Phragmites* sp. commonly referred to as pit-pit, are found. The work of clearing and preparing such areas is considerably greater than the grasslands. After the initial cutting by hand of the dense pit-pit stands, grubbing operations are then necessary to dig and cut out the firmly rooted stumps of the pit-pit. It is essential that the grubbing operations be very thorough in order to ensure that all of the proposed planting area be well cultivated to a depth of at least 12-15 inches, and that most of the extensive root system of the pit-pit species be removed or killed. Careless clearing of such land will result in a persistent regrowth of the pit-pit species.

Lining.—

Once the lands has been cleared it is desirable to line and hole the area without undue delay. By completing these operations early it is then possible at the beginning of the wet season to concentrate the labour force on getting the temporary and permanent shade established.

The combined operations of lining, holing and establishment of shade, entails much time and labour. Growers are advised not to overestimate their labour potential but to concentrate their efforts and attention on a manageable area in order to complete the operations quickly and successfully.

The lands may be lined out either on the square or triangle. The latter system is preferred as it results in 13 per cent. more trees per acre. For lining out a non-stretchable wire is necessary. Piano wire is quite suitable for this purpose.

The recommended spacing is 9 feet x 9 feet. For multiple-stem coffee it may be better to allow for a slightly larger spacing, perhaps 10 feet x 10 feet. In higher rainfall areas, or areas of very fertile soils, the spacing could possibly be slightly closer. In lower rainfall areas, however, the tendency should be to increase the spacing between the trees to allow each individual tree a wider soil area on which to draw moisture.

With a view to mechanised plantation management in the future, it may be practical to increase the spacing between the rows and decrease the spacing between the trees in the row. For example, rows 13 or 14 feet apart with the coffee trees 6 feet apart in the rows would allow the passage of vehicles through the plantation, without loss of space or plantings. This could be of practical benefiit in the future with respect to mulching, fertilizing and weed and pest-control spraying programmes.

Holing.—

Once the land has been cleared and lined, holing should commence immediately.

Although there is quite a variance of opinion among growers as to the size of the planting holes, large holes, $2\frac{1}{2}$ feet x $2\frac{1}{2}$ feet are recommended. It is of interest to note the results obtained from experiments in Kenya with regard to the size of the planting hole and the subsequent coffee yields.

During the digging of the holes the top-soil and subsoil are separated, being thrown to opposite sides of the hole. It is desirable that the sides and bottom of the hole not be cut with a smooth finish as this will tend to decrease moisture penetration and the rate of weathering. The bottom of the hole should be loosened when the holes have been dug to full depth.

It is recommended that the holes be dug at least three months prior to planting to permit weathering and moisture penetration. Three to four weeks before planting is due the holes should be refilled with

topsoil only and a small mound formed over each hole to allow for sinkage of the soil. After the holes have been refilled the mounds of subsoil are levelled over the surface and a general relining of the planting pegs is completed.

Establishment of Shade and Windbreaks.—

The coffee plant in its natural habitat is a forest plant and as such it requires some form of protection from wind and exposure to direct sunlight for prolonged periods.

Whether the protection from direct sunlight be from cloud formations or provided vegetative cover is immaterial. The important fact to be borne in mind with respect to coffee plantings in the Highlands is that the coffee plant must be provided with some form of shelter, particularly during the drier months of the year. The provision of ample shade and correct shade manipulation during all stages of growth of the coffee plant is a prerequisite for successful coffee production in the Highlands.

The amount of shade necessary is determined to a degree by the environmental conditions on each plantation. In the lower rainfall areas of the Highlands it is natural that a greater density of shade would be required in comparison with the higher rainfall areas. Also plantings at lower altitudes would require more shade than plantings at higher altitudes. Furthermore it should be remembered that the shade provided should be manipulated. More than purely a matter of shade provision, it is a matter of shade control. Controlled so that the shade may be thinned out by pruning during the wet months of the year when the coffee plant is actively growing and increased in density during the hotter, drier months. Local experience and observation are necessary to determine the optimum shade requirements for each area. The amount of shade necessary may also be influenced by cultural operations, particularly mulching and irrigation. It is noticeable that well-mulched plantings exhibit a greater degree of tolerance to wilting and exhaustion during the drier months.

The lack of adequate shade in most parts of the Highlands, especially below the 5,500 foot contour, results in premature cropping or overcropping of the coffee plant. Overcropping is primarily the cause of "die-back" and consequently biennial or triennial bearing. Wherever shade is used it affects flowering and tends to produce even crops in successive seasons.

Where the temperatures are too high and prolonged and the rainfall too low, the trees overbear their strength. The result is a bumper crop one year followed by exhaustion and "die-back", and at least two years of low yields. Shade has the effect of reducing the numbers of flowers produced to within the bearing capacity of the tree to crop without exhaustion.

In the Highlands the unshaded coffee plant rather than developing vertically tends to develop more of a compact shape. The spacing between the internodes become closer and the number of primary laterals arising from the main stem becomes greater. The increased lateral growth in itself presents an additional pruning problem that is not encountered on the shaded coffee tree. The numerous pairs of closely spaced primary laterals in turn develop a vigorous growth of secondary laterals close to the main stem, rather than developing in length and vigour as is expected with the primary lateral growth of shaded coffee trees. It is the excessive growth of primary and secondary laterals, particularly on immature trees, which predisposes the tree to exhaustion and "die-back". The coffee plant has not developed sufficiently to mature such a heavy crop. Part of the crop fails to mature and ripen and dies on the tree.

Where the coffee tree is grown with ample shade, or where the environmental conditions are not conducive to over-cropping, there is not such a profuse lateral growth. Also the internodal spacings are wider, and the primaries tend to develop more in length and vigour, rather than developing a premature excessive growth of secondaries and tertiaries. Thus in the early bearing years particularly, the tree has not an excess of bearing wood and so does not carry too heavy a crop to mature. Furthermore the trees will tend to bear an average crop each year, rather than developing a triennial cropping cycle of heavy and light yields.

To prevent overbearings and "die-back" with unshaded trees, crop stripping and

judicious and fairly constant pruning are necessary. Good plantation management aims at regular crops and a minimum of labour. Intelligent shade management will aid this aim and obviate the practice of crop and flower stripping, and undue pruning when the crop is considered too large.

It is recommended that both the temporary and permanent shade be planted as soon as possible after clearing and holing. The temporary shade will help to depress weed growth. Also it is desirable that the temporary shade provide sufficient shelter for the coffee seedlings when planted, otherwise shade shelters are necessary for each seedling.

Growers should bear in mind that it is much easier to remove shade from an area rather than establish shade in an area of established coffee plantings. Hence in the Highlands, when planting the larger tree species, an initial spacing of 18 feet x 18 feet is recommended. As the shade trees mature and the overhead canopy develops the trees may be thinned out and pruned to give the optimum amount of shade. The final tree spacing may be in the order of 54 feet x 54 feet. It is recommended that the permanent shades species be planted in the coffee rows, so as to allow easy access between the coffee rows.

Qualities of a Permanent Shade Tree.—

When selecting a suitable permanent shade tree it is desirable that the tree :

1. Have a long life.
2. Be leguminous.
3. Be strong wooded and not liable to wind damage.
4. Have a spreading habit and provide a filtered shade.
5. Be easy to propagate and able to stand pruning and lopping.
6. Should not be a tree which is a host for any of the serious pests or diseases of coffee.
7. Be resistant to insect pest and disease attack.
8. Have a tall growth habit to clear the coffee bushes, and a deep root growth system so as not to compete with the coffee bush for soil nutrients.

There is no tree available in the Highlands which fulfils all of the above desired requirements. The following descriptions cover the tree species used in the Highlands for coffee shade.

Albizzia stipulata is the Departmental recommendation and appears as the most suitable of the current shade species. It is fast-growing, leguminous species, with a spreading habit, fairly deep rooting and providing a filtered shade. It is relatively resistant to disease and insect pests, and stands lopping and pruning well. Easily propagated from seed and cuttings. However, it requires protection from strong winds as it is fairly susceptible to wind damage.

Observations indicate that the endemic *Albizzia* sp. commonly referred to as the Wabag Albizzia, is not very suitable. The trees have a massive and rather shallow root system, are inclined to be brittle, are subject to defoliation by mealybugs (*pseudococcus* sp.) and leaf-eating caterpillars during the dry season, and provide a dense rather than a filtered shade.

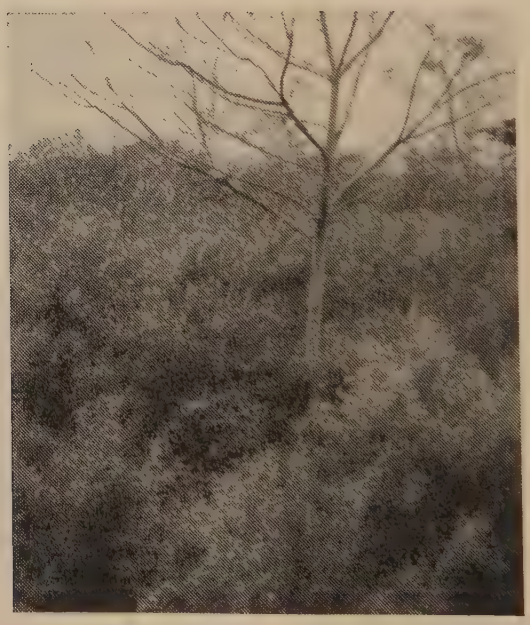
Another of the endemic *Albizzia* sp. occurring in parts of the Bena area appears preferable to the Wabag Albizzia. The former is feathery-leafed, very quick-growing, and it not at this stage subject to defoliation by the same insect pests defoliating the Wabag Albizzia sp.

The *Erythrina* species are not recommended as they lose their leaves during the dry season and are periodically defoliated by caterpillars.

Although some plantings of *Grevillea robusta* have been made, none of the plantings has developed sufficiently as yet to allow assessment of their value as a potential shade species. It is noted, however, that *Grevillea robusta* is a fast-growing species in the Highlands.

Although *Leucaena glauca* does well in the Wau district, altitude approximately 3,000 feet, it has failed to produce similar growth in the eastern and western Highlands. About 16 feet in height appears to be the limit of its growth. The growth rate is very slow compared with that at lower altitudes. Inoculation of *Leucaena* seed with strains of *Rhizobium* isolated from

Development of permanent shade "Albizzia stipulta" in coffee block. Shade 2½ years old.



Wabag "Albizzia" sp. as permanent shade defoliated by mealybugs and leaf eating caterpillars.

Leucaena at Keravat, apart from providing an initial growth response, has not improved the general growth rate of *Leucaena glauca.*

The common Highlands *Casuarina* sp. appears to be a suitable shade tree for coffee, especially after the coffee has become reasonably well established. In the Highlands wherever mature coffee is found growing under established *Casuarinas* the coffee bushes in most instances are very vigorous in growth and healthy in appearance. It is recommended, however, where *Casuarinas* are to be used as a coffee shade species, that there should be adequate soil moisture throughout the year, either from natural sources or irrigation.

Coffee seedlings in nurseries under, or in close proximity to *Casuarina* trees, make slow growth in the early stages of development. This is believed to be due mainly to the strong competition from the *Casuarinas* for soil moisture.

There is substantial evidence to indicate that some *Casuarinas* possess soil nitrogen-fixing properties. Also that the nitrogen content of the leaf fall is comparable with that of many leguminous tree species. Root nodules have been noticed on the Highlands *Casuarinas* species, believed to be *Casuarinas equisitifolia.*

Temporary Shade.—

For a temporary shade species the desirable characteristics are :

1. Leguminous.
2. Rapid growth rate of at least six feet.
3. Free seeding habit and seed easy to harvest.
4. Ease of establishment.
5. Ability to persist for at least eighteen months.
6. Resistance to pests and disease.
7. Ease of eradication when necessary.
8. Resistance to wind damage.
9. Not a host plant for serious coffee pests or disease.

Crotalaria anagyroides is the accepted temporary shade species in the Highlands. It is a quick-growing, leguminous shrub, with a prolific seeding habit, easy to establish, and is rather resistant to wind damage. Given moist conditions it will provide satisfactory shade and shelter within three months, and will persist as an effective shade and shelter plant for at least eighteen months. It is very susceptible to attack by Black Scale (*Saissetia nigra*) and the Crotalaria Leaf Mosaic virus.

Tephrosia candida is a woody shrub growing to a height of 12 to 14 feet. It is slower growing than *Crotalaria* but will persist for at least three years. It has not been used to any extent in the Highlands because of its slow growth and rather poor seed set for the first year or two. There is also evidence to indicate that it competes strongly with the coffee plant for soil moisture. This competition may have a retarding effect on the coffee plant during the drier months of the year.

Tephrosia vogelii is smaller than *Tephrosia candida* but has a more sprawling habit of growth. It is slow-growing and does not appeal as a temporary shade species.

Cajanus indicus (Pidgeon Pea). This plant grows very rapidly, attaining a height of five to six feet. It is not recommended as it is short lived compared with *Crotalaria* and *Tephrosia* and is very susceptible to insect attack.

Bananas are not recommended as a temporary shade species. They compete for moisture and soil nutrients, require extra management and are troublesome to eradicate once established.

Planting the Temporary Shade.—

The *Crotalaria* seed should be planted as soon as possible after the end of the dry season. If planted during October it will be eight to ten feet in height by the beginning of the following dry season, May-June. The recommended method is to plant the *Crotalaria* in parallel lines between the coffee rows. Shallow drills are made running parallel to the lines of coffee holes and the *Crotalaria* seed sown thickly in the prepared drills. It is advisable to dust the drills lightly with an insecticide prior to sowing to minimise attack by cutworms on the germinating *Crotalaria* seed. Aldrin No. 5 dust has proved very effective.

In some cases, every second row only of the *Crotalaria* is planted. Then as the *Crotalaria* begins to weaken towards the

end of its second year, the previously unplanted alternate lines are planted. The older *Crotalaria* rows are then removed and used for mulching between the coffee rows. This latter system of planting has proved quite successful and is gaining in popularity. Usually the *Crotalaria* is planted in a north-south direction so as to obtain the maximum shade benefit. However, should there be prevailing winds from a southerly or northerly direction it is advised that the *Crotalaria* rows run east-west, that is at right angles to the prevailing wind. Priority is thus given to the windbreak factor rather than the shade factor.

Previously in some plantings the *Crotalaria* was planted in the same row as the coffee and the permanent shade. This method of planting proved unsatisfactory as a result of the heavy incidence of Black Scale infestation on the *Crotalaria*. The waxy exudate from the Black Scale, by fall-

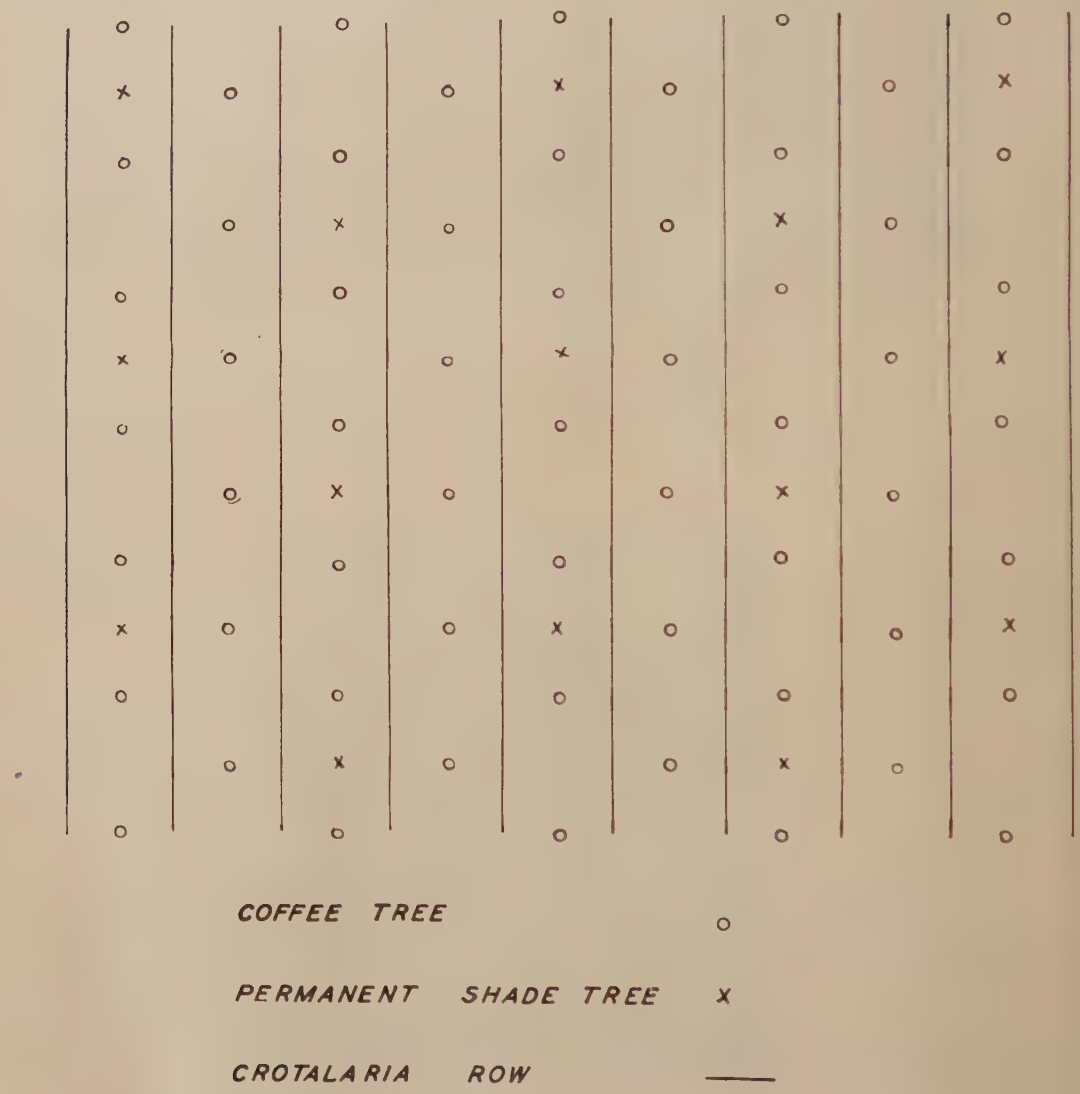


FIGURE 1 SHADE PLANTING DIAGRAM

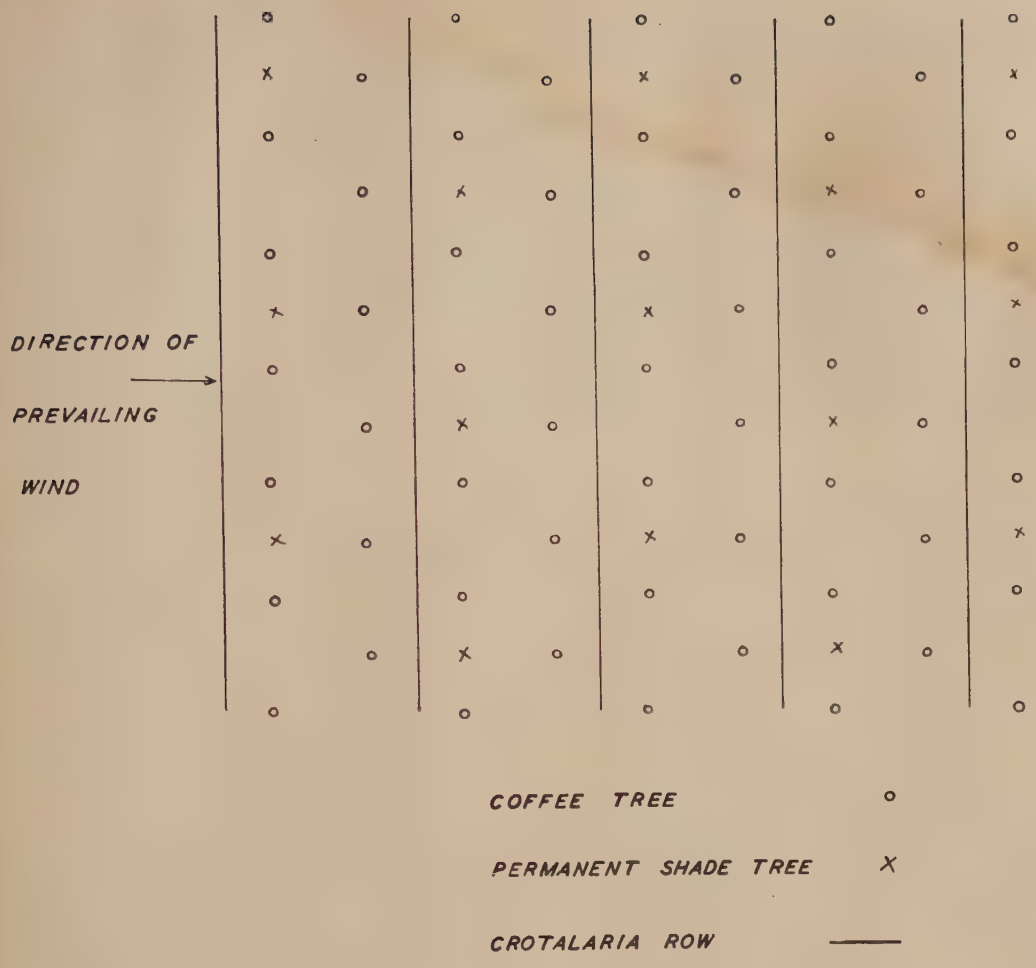


FIGURE 2 ALTERNATIVE SHADE PLANTING DESIGN

ing on to the leaves of the young coffee plants, resulted in the appearance of the Sooty Mould fungus on the leaves of the coffee plant. To a lesser degree Sooty Mould formation may also occur as a result of the presence of Green Scale (*Coccus viridis*) on the young coffee growth. As the *Crotalaria* ages and weakens it becomes heavily infested with Black Scale. The *Crotalaria* overhanging the coffee plant allows the exudate from the Black Scale to fall on to the coffee leaves, hence the attendant Sooty Mould formation.

The Sooty Mould by forming a surface film on the upper epidermis of the coffee leaves, minimises photosynthesis by the coffee leaf. In response the coffee plant tends to produce a spasmodic growth of numerous chlorotic suckers on both the main stem and laterals. The Sooty Mould disappears on removal of the *Crotalaria* or the Green Scale.

By planting the *Crotalaria* in between the coffee rows it can be trimmed so as not to overhang the coffee plants. This greatly minimises the incidence of Sooty Mould.

Windbreaks.—

Many coffee plantations in the Highlands are exposed to strong, prevailing winds at certain times of the year. The use of substantial windbreaks is strongly recommended in all such cases.

The mechanical and physiological damage to the coffee plant that may occur as a result of strong winds should not be underestimated. In extreme cases it has been noted that strong winds have stripped the new flowers from the coffee plant on the unprotected windward side of the tree. Hot, dry winds cause excessive wilting of the coffee leaves.

A number of tree species appeal as suitable windbreak species. The local *Casuarinas, Grevillea robusta* (Silky Oak), and *Eucalyptus deglupta* (Kamarere), are preferred. All are fast-growing, erect species in the Highlands.

Plantation Management.

Allowing that all the phases of the land preparation have been carefully and correctly completed, the foundations of a successful plantation are laid in the nursery and the growth of the tree during its first few years in the field. Correct nursery management and intelligent cultural practices in the field are the key-notes of successful plantation management.

Selection and Preparation of Seed.—

Propagation from seed is the commercial method of establishment for coffee plantings in the Highlands. The Department of Agriculture, Stock and Fisheries, has demonstrated methods of vegetative propagation. However, the high degree of self-pollination in coffee plants, plus the need for more testing of clones, indicates that it is unlikely that vegetative propagation will be used for commercial plantings for some time at least.

For a more detailed account of the current experimental work being conducted by the Department of Agriculture, Stock and Fisheries, with regard to the vegetative propagation of coffee, see "The Vegetative Propagation of *Coffea arabica* L." by A. J. H. van Haaren, *Papua and New Guinea Agricultural Journal*, Volume 10, No. 2, October, 1955.

Usually the seed is obtained from the Department of Agriculture, Stock and Fisheries. In some cases growers prefer to select local seed. In such cases it is usual to obtain seed from selected mother trees. As the coffee plantings in the Highlands are all of recent vintage, one cannot select old and proven trees, as is the custom in selecting mother trees. However, attention should be paid to the following factors when selecting local mother trees:

1. Select trees which are high yielding and have large beans.

2. Select trees which are vigorous. Observe that the tree is naturally vigorous.

3. Select trees which appear true to type.

In making the field selections ensure that the tree is naturally vigorous and high yielding and not because the lack of competition or some other helping factor has given the tree extra vigour and yield compared with neighbouring trees.

Fully ripened cherries are picked and pulped by hand or in a hand pulper to avoid damage to the parchment. Light beans are floated off and all malformed and small beans discarded. The fresh sticky parchment is then rubbed in wood ashes and partially dried in the shade and not in direct sunlight. The wood ashes adhering to the parchment skin, forms a protection coating which prevents hardening and splitting of the parchment.

For best germination results the coffee seed should be planted as soon as possible after the partial drying. It is obvious that the viability of coffee seed declines after some weeks of storage. The germination of old seed can be improved by soaking in water for twenty-four hours prior to planting.

Preparation of the Nursery.—

A flat or only gently sloping site, with a deep, fertile soil is recommended. Good drainage is essential. It is important that the nursery site be in a sheltered position but not under trees or permanent shade.

It is recommended that the nursery beds be five feet in width and of any convenient length. The five foot width is selected as it allows ample space for four rows of seedlings to develop fully in the nursery beds and be root-pruned prior to transplanting. Table 3 illustrates the planting designs for the seed-beds.

The ground should be well dug and freed of weeds, tree roots and stones, but care must be exercised not to bring the heavier

subsoil to the surface. For convenience the beds should be separated by three-foot wide pathways. To facilitate drainage the beds are raised about six inches above the path level using the top soil from the paths.

Protection of the seedlings from direct sunlight is essential. For convenience a framework of posts and crosspieces sufficiently high to allow the workers to stand underneath is recommended. The actual shade is then arranged by placing pit-pit, and other grass materials over the top of the framework and securing so as to prevent it from being blown away. The shade may be easily regulated by either removing or adding further shade material.

In cases where rough building materials are in short demand adequate shade shelters, no more than two feet high may be constructed directly over each nursery bed, leaving the pathways quite free. It is desirable that the shade shelters be completed prior to the planting of the seed.

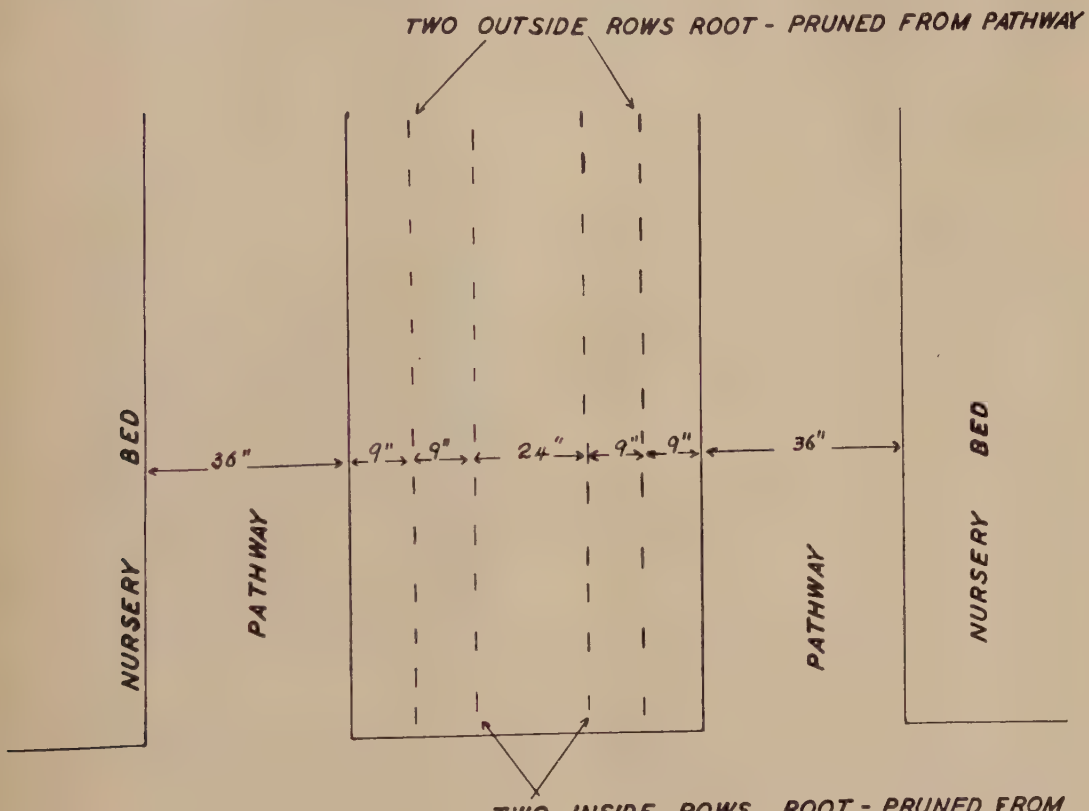


FIGURE 3 DESIGN FOR COFFEE NURSERY BEDS

Nursery Practice.—

The seed should be sown in drills with an interval of nine inches between the drills and the seed six to nine inches apart in the drills. The surface soil must be loose and the coffee seed should not be planted more than about half an inch deep. Too deep plantings result in delayed and spasmodic germinations.

Whilst the seed is germinating it is important that the nursery beds not be allowed to dry out. A complete mulch of fine grass will prevent drying out and packing of the surface soil. When the seedlings begin to emerge the mulch should be removed and the overhead shade increased. Germination normally occurs six to nine weeks after planting.

When the seed has germinated care must be taken to ensure that the young plants do not wilt from the drying out of the nursery beds. Watering and mulching will ensure that moist soil conditions are maintained. As the young plants develop, weed out any malformed or " off-type ' seedlings. Retain only normal, vigorous seedlings. Keep the nursery beds free from weed growth.

In East Africa and Hawaii the normal practice is to sow the seed thickly in the drills and transplant the seedlings to seedling beds as soon as the first pair of true leaves appear.

Whilst the seedlings are developing in the nursery close attention should be paid to the regulation of shade. Overshading will result in long, whippy seedlings, whilst the lack of adequate shade results in retarded growth, sunscorch and yellowing of the leaves. About two months before transplanting the shade should be gradually removed by stages until there is no overhead shade for a short time preceding transplanting. This is to harden-off the seedlings in readiness for field planting. The seedlings are usually left in the nursery for from twelve to eighteen months.

Six to eight weeks prior to field planting it is recommended that the seedlings be root-pruned by root-snapping. This practice was demonstrated by Y. Baron Goto during his visit to the Highlands coffee areas and is considered to be a procedure that should be adopted by all coffee growers, as it avoids the all too common complaint of " bench tap-root ". To root-prune, a spade is inserted into the ground about four inches from the base of the seedling. The handle of the spade is then tilted downwards slightly until a distinct snapping sound is heard from under the coffee seedling. The sound is the complete snapping of the root system of the seedling. The spade is withdrawn and the ground firmed down around the base of the plant.

The severance of the root system of the actively growing seedling has the immediate effect of inducing the injured plant to produce a tremendous regrowth of new lateral roots from the severed roots.

The mass of new roots produced within six to eight weeks is so complete as to completely bind and hold the sod of soil enclosed by the growing root system. On transplanting it is then a simple procedure to transplant the coffee seedling into the field complete with the sod of soil from the nursery. By this method there is very little interference with the root system on transplanting, wilting of the plant should not be evident, and the seedling should suffer very little initial setback as a result of the transplanting. Serious wilting of coffee seedlings after transplanting is a common feature of new coffee planting in the Highlands. This is due mainly to the varied transplanting techniques adopted by individual growers.

Should it be intended to adopt the Kenya system of either single-stem or multiple-stem pruning, it is recommended that the seedlings be capped in the nursery. The seedlings should be capped at no higher than fifteen inches from the ground and at least one month prior to transplanting.

Transplanting.—

The importance of careful and correct transplanting cannot be stressed too strongly. It would be no exaggeration to say that no other single phase of plantation establishment is more important than the successful transplanting of the coffee seedlings from the nursery to the field. For successful transplanting the following recommendations are of importance :—

1. Do not delay in transplanting.

Plant during the early part of the wet season to allow the coffee seedlings to

become firmly established before the onset of the dry season is expected.

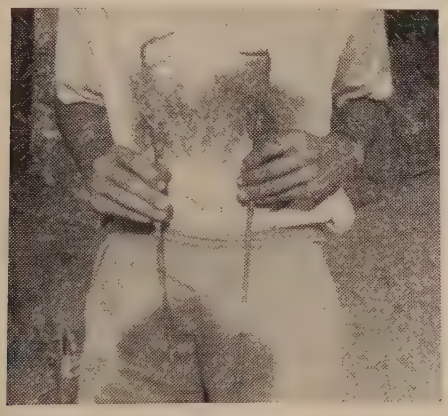
2. Eliminate as much as possible the time lag involved in moving the seedlings from the nursery to the field.

The shorter the time lag the less likelihood there is of the seedling wilting and receiving a temporary growth set-back. Hence the advantage of siting the nursery as near as possible to the proposed planting area.

3. Ensure that the seedling root system is covered by wet hessian bags or something similar, during the time that the plant is out of the ground.

Do not on any account allow the young roots to be exposed to either sun or wind.

4. Prune any long tap-roots or lateral roots prior to planting. If planting in the sod, prune off any roots extending more than a few inches outside the sod.



Bench tap-root condition of young coffee plants.

By cutting back the tap-root the common fault of "bench tap-root" is eliminated. Bench tap-root is the direct result of the bending, at an acute angle, of the lower part of the tap-root when planting the seedling in the field. It is largely a result of hurried and careless plantings. Coffee seedlings so planted do not develop into vigorous trees. Outwardly they may appear to develop quite normally for some time but quickly wilt and evince signs of "die-back" during a dry spell or when bearing the first full crop.

5. Do not plant too deeply. This has been a rather common fault with coffee plantings in the Highlands. The result is usually debilitated, stunted plants or premature "die-back" of young bearing plants.

The coffee plant is essentially a surface feeder and when planted too deeply the surface feeding roots are poorly developed or may even be lacking altogether. Over-deep plantings can usually be detected in a plantation by their debilitated appearance and by shaking the main stem of the tree. In the case of over-deep plantings, there is quite a free sideways movement of the main stem when shaken. This is due to the poor development of the surface feeding roots after transplanting. Consequently the tree becomes undernourished and is loosely anchored in the ground.

6. Plant on a dull day.

Dull and calm weather is advised for planting. If the days are hot and sunny it is wiser to plant in the late afternoon.

7. Reject any weak, stunted or atypical seedlings and seedlings with a malformed root development.

8. Provide shade and shelter for the seedlings immediately after transplanting.

Immediately after transplanting, seedlings should be shaded and mulched and protected from winds. Should the temporary shades species be insufficiently developed, then temporary shelters of grass or pit-pit material should be erected for each seedling. A circular shelter giving wind protection is preferred to the roof-top or overhead shelters.

Pruning.—

Careful and correct pruning is a most important cultural practice for successful plantation management. Improper pruning can materially reduce yield and subject trees to biennial or triennial bearing, often resulting in "die-back". It behoves the grower therefore, to prune correctly for efficient annual production and healthy trees.

In the Highlands both the single and multiple-stem pruning systems are practised. Growers are adopting the Kenya and Hawaiian pruning systems, with various modifications, for both single and multiple-stem coffee.

Single-Stem Pruning.—

The important thing to be kept in mind during the first three to four years of the life of the coffee tree is that every care should be taken to ensure that the young growing tree develops strong lateral branches and a strong main stem. If the laterals are strongly developed in the early years of growth, then providing they are well cared for, they should bear a good average crop for many years.

Should the lower side branches (primary laterals) die right back to the main stem, they can never be rejuvenated or replaced at that spot. It is the lateral branches which bear the crop, hence every care should be observed in preserving these bearing branches and ensuring that they become strongly developed as they are the fruiting framework of the bearing tree.

Shaping the Single-Stem.—

1. The young seedling is capped at about fifteen inches above ground level. It is recommended that the capping be done in the nursery about one month prior to planting. At the same time it is advised that the two top primary laterals be cut back to just beyond the first pair of mature leaves. If this is not done the weight of the two top branches may cause the main stem to split at the top.

2. Capping the tree induces it to produce suckers. To ensure maximum development of the main stem and laterals, these suckers should be removed.

3. When the lower side branches have developed satisfactorily, one sucker is then allowed to grow up from the top of the capped tree. On reaching waist height, this stem is capped as before and the two top laterals cut back to the first pair of mature leaves.

Again it is recommended that no suckers be allowed to grow up after capping until the young primary laterals in the middle of the main stem are well developed. In East Africa is is recommended that no suckers be allowed to grow up for at least six months after capping.

4. Once satisfactory development of the upper side branches has been attained, then one sucker should be allowed to grow up as before. This is capped at approximately five feet from the ground.

Remember—

(*a*) Do not allow the tree to carry too heavy a crop while it is still immature—while the young root, stem and leaf systems are insufficiently developed to bear and mature a heavy crop.

(*b*) It is wiser to adopt a long term attitude and have a tree which has the strength and vigour to bear a good crop for many years, rather than a weak, low-yielding tree.

(*c*) Have sharp pruning implements and prune fairly close to a bud so that the wound heals quickly.

Pruning the Single-Stem Tree.—

(*a*) *Remove—*

1. All secondary laterals which grow out from the primaries within at least one hand's span of the main stem. This is to allow adequate aeration and light into the centre of the vegetative framework of the tree.

2. All branches that are growing in towards the centre of the tree or are not growing in the right direction.

3. All deadwood and all thin and whippy branches.

(*b*) Where secondaries grow out in pairs from the primaries remove one secondary so that at each node on the primary one secondary grows out alternately.

(*c*) Where tertiary branches grow out in pairs from the secondaries, remove also each alternate tertiary branch.

(*d*) Remove suckers before they become too big.

(*e*) It is recognized that the best framework for a single-stem tree is one that has widely spaced horizontal branches. If the primaries are too closely spaced, remove alternate ones to allow for ample light and aeration of the interior of the tree. This will also help to prevent certain insects from harbouring in the trees.

(*f*) During the wet season remove all new suckers and new secondary branches growing out close to the main stem. No other pruning is recommended for this time.

Pruning of the single-stem tree should have as its most important objective the preservation of the strength of the primary

branches as the tendency is for them to weaken with each successive crop and to lengthen their bearing tips too far from the main stem. If they are permitted to do this they grow spindly and droop. Successive prunings should aim at cutting back the overlong primaries to strong secondaries, thus arranging for secondaries to replace the primaries that have grown too spindly. Meanwhile, all the sucker growths that sprout from the main stem are pinched away at regular de-suckering intervals which should be sufficiently frequent to prevent these growths being more than a few inches long.

Hence it can be seen at once that the selection and thinning of secondary growths becomes a somewhat complicated pruning procedure, necessitating the use of intelligent and skilled pruners. Also it is a costly procedure since careful pruning may take upwards of ten minutes per tree for some trees.

Multiple-Stem Systems of Pruning.—

In the Highlands several multiple-stem pruning systems are being followed. Growers are adopting mutiple-stem systems, according to their individual preferences, based on either the East African multiple-stem system, a modified Agobiada system or a form of multiple-vertical pruning as practised in Hawaii.

East African Multiple-Stem Pruning.—

The vertical framework is developed by capping the young seedling at about fifteen inches from the ground, in the nursery or after planting in the field. Two suckers then develop on either side of the capped stem and usually other suckers will appear below. These suckers form the vertical growths.

The usual practice is to obtain three or four sturdy upright growths and have them growing up together about the same size and of equal strength. Should only two verticals develop from the capping, either one or both of the verticals may be topped to produce three or four verticals as desired.

As the verticals develop upwards the branches will be interlaced in the centre of the tree. However, as the verticals become taller the weight of the crop on their upper branches and the pulling of the pickers to reach the fruit soon forces the vertical stems to bend away from each other. Thus the centre of the tree is opened up and the interlacing branches are pulled apart.

As the upright stems become taller the lower laterals bear crops, become exhausted and are of no further use to the tree. They are then pruned away flush with the main stem. Hence as the uprights become taller they will become bare of growth further and further up the stem as the exhausted laterals are progressively removed. Only unproductive and dead wood is removed. Pruning is therefore quite simple and well within the scope of unskilled pruners, once they have been shown the fundamentals of the multiple-stem pruning.

In the multiple-stem pruning as distinct from single-stem, the main stems (verticals) are not capped. If the stems are capped they will tend to become too strong and woody. This is to be avoided as the stems cannot bend easily when carrying a heavy crop and may snap off under windy condi-

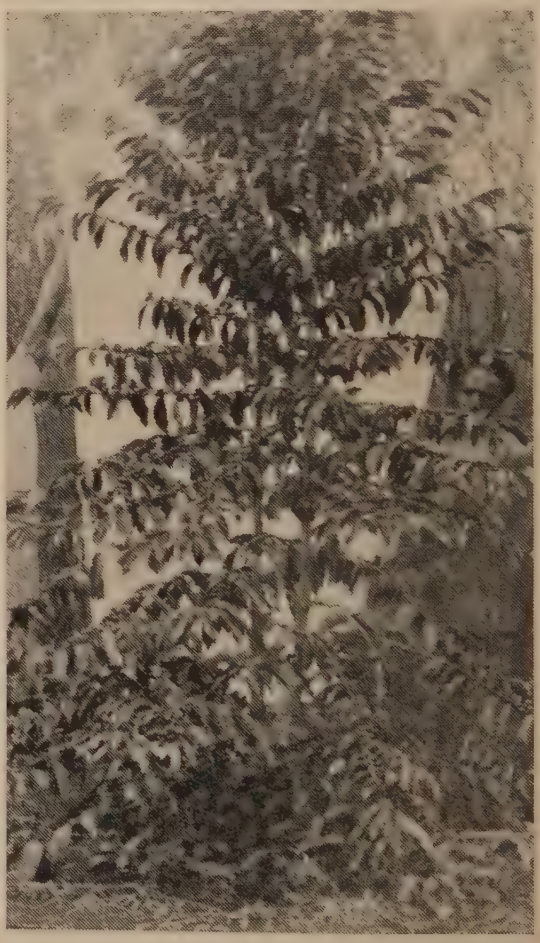
A nature single stem coffee tree showing excessive vegetative growth.

"Die back" of single stem coffee showing lack of shade, excessive lateral growth and dry immature cherries on leafless branches.

tions or when the crop is being harvested. As also with single-stem coffee, care must be exercised to ensure that the trees do not overcrop. Overcropping can be easily controlled by pruning further up the verticals.

After the stems have begun to bend away from each other with the weight of the crop, harvesting may be done with a short step-ladder or by pulling down the branches within reach. However, there comes a time when by the use of foresight and experience it will be seen that the old stems have grown too tall and spindly. Meanwhile, it may be seen that young sucker growths have begun to sprout from near the base of the tree. Those suckers that originate from too high up on the main stems should be pinched away. Of those growing near the base, one or two of the best may be selected to grow in succession to replace the old main stems. As these mature and grow upright in the centre of the bush, they will in turn begin to form laterals and it is at this time, that one or more of the older stems may be sacrificed and cut back to near the base, so that the younger verticals may take their place.

The aim is to cut back the older stems in succession, perhaps one each year, so that the younger verticals also replace them in succession, thus simplifying the pruning schedule. If sucker growth does not sprout of its own accord, then one of the main stems can be cut back a little earlier so that sprouts are obtained from its stump. Until new sucker growth does appear, it is advised that the main stem be only partly severed at the base by sawing about half-way through the stem and bending it over slightly. This will have the effect of inducing a more rapid sprouting of suckers. The main stem may then be completely removed by sawing right through the stem.



A young well developed multiple stem coffee tree.

Should it be desired to produce suckers on one side only of the vertical then remove nearly all the primary growth on that side only of the vertical. Suckers will then sprout from the bare side of the vertical. This method of sucker formation has been adopted in the Highlands to form new suckers on the eastern side of the stem. The young suckers are then not liable to leaf scorch as they are protected from the hot mid-day sun by the parent tree.

Agobiada Multiple-Stem System.—

The difference between Agobiada system and East African multiple-stem system is that the seedling is bent over and not capped to produce verticals for the first cycle.

In the Agobiada system the young uncapped seedlings are planted in the field and allowed to grow to about waist height. The tip of the main stem is then bent over and pulled down until it touches the soil and is fixed in this position either by being pegged down by a stout, hooked stake, or is secured to a peg fixed in the ground. Before bending over it is recommended that the lower laterals be pruned away, so that the sturdier portion of the bent arch is bare of growth.

It does not take long for new uprights to sprout from eyes along the bent portion of the stem. Three of the best that grow from where the arch begins and are evenly spaced, are selected to form the multiple-vertical tree. The growth of the new uprights is rapid and by the time they have in turn developed laterals, the arched stem of the original seedling has thickened and become set. It will not then spring back into an upright position when released. The original stem will also have grown longer and may have begun to curve upwards at the tip. Some of its laterals may have begun to bear a "fly" crop of fruit and under the true Agobiada system the tip would be released and would be allowed to remain as part of the tree. Usually, however, the old stem at this stage is cut back to where one of the new uprights has grown.

Subsequent pruning for the Agobiada system is identical with that for the East African multiple-stem system.

Hawaiian Multiple-Vertical System.—

The Hawaiian method of developing the multiple stem framework is somewhat similar to the Agobiada system. However, the Hawaiian practice is to plant the seedling in the field at an angle of 45 degrees. This has the effect of promoting a growth of verticals from near the base of the main stem. Thus the verticals for the first cycle of the multiple-vertical system are initiated.

Four verticals evenly spaced around the main stem are selected. All other verticals are then removed. When the selected verticals have developed sufficiently, the top of the original main stem is then cut back to the nearest upright.

Early development of a tree pruned to the Agobodia system.

Advanced development of a true pruned tree to the Agobodia system.

The four verticals are cropped for several years, then the least vigorous of the four is removed at the base. A new vertical is allowed to come up as a replacement. Basically then the pruning consists of removing one of the older verticals each year and allowing a new upright to come up as a replacement. This means that the tree is cropped and pruned to a four-year cycle, thus completely renewing the tree every four years.

An alternative system allows for six verticals in the framework. This system is recommended for areas favoured with higher rainfall and more fertile soils. The older verticals are replaced as in the former system but in the six vertical method, two verticals are replaced every other year and one each alternate year, so that the tree is again completely renewed every four years.

Other systems of multiple-stem pruning are practised in various coffee producing countries, but appear to be only of local importance and are not conducive to high average yields and good quality.

In theory the multiple-stem system of pruning is preferable to single-stem because the tree and its root system are constantly given vigour by the continued formation of new verticals. At the same time all weak and exhausted branches are removed so that they do not deplete the tree of its strength. This should lead to more regular yields and to heavier yields than single-stem trees.

Irrespective of the foregoing remarks, the multiple-stem methods of pruning are easier and far more economical to carry out, especially when pruners are not highly trained. Regular pruning is an essential phase of correct plantation management. It requires a certain amount of skill, plus time and labour. Hence serious consideration should be given to adopting a pruning practice that requires a minimum of labour and skill—one that is easily adaptable to the indigenous labour.

Conversion of Single-Stem to Multiple-Stem.—

Single-stem trees may be converted to multiple-stem by stumping-back.

Normally there will not be any laterals low down on the stem of the single-stem tree. Hence to convert such trees to multiple-stem, the tree should have all the primary branches removed except for a few at the top and no crop should be allowed on the branches that remain. The top branches will help to feed the roots until suckers have grown from the main stem, encouraged by the shock given to the tree by the removal of most of its primaries. To encourage suckers to sprout from the basal part of the tree, a fairly deep saw cut is made in the main stem just above where it is desired that the new suckers appear. In due course a healthy bunch of suckers appear around the basal part of the main stem. When these begin to form primaries the top part of the tree is completely removed by sawing through at the partly severed point on the trunk. Stumping should not take place until after the beginning of the wet season. At the same time

Advanced stage of development of first cycle of Hawaiin system of multiple stem pruning.

any surplus suckers are removed, leaving the three or more selected verticals spaced around the stump. A slanting cut is advised when stumping-back a thick trunk.

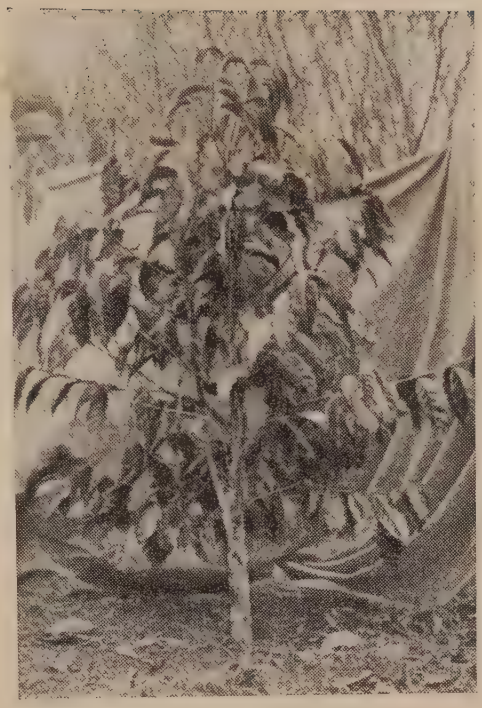
In this manner an old plantation of single-stem trees may be converted to multiple-stem in the safest way. Any one of the afore-mentioned multiple-stem pruning systems may be used after the verticals are established.

Basically then, the single-stem system relies on preventing a rapid upward growth of the main stem to final height and pruning to carry the crop on the secondaries and tertiaries, rather than on the primary laterals. On the other hand all multiple-stem systems rely on a rapid growth of the verticals and the crop to be borne mainly on the primary laterals.

When to Prune.—

There is quite a degree of variance among overseas authorities as to which time is considered the correct time to prune coffee.

In both East Africa and Hawaii it is maintained that pruning is most profitably and effectively done immediately after harvesting or during the semi-dormant period



Advanced development of a tree after conversion from single to multiple stem pruning.

Mulching of coffee showing bundles of grass being carried into the block.

following the harvest when rainfall is lowest. In regions where the harvesting period may continue throughout the year, as in cooler higher rainfall areas, it may be necessary to prune at various times. The alternative opinion is that the coffee tree be pruned shortly after the main flowering, when the trees have formed small, immature fruits. However, all authorities agree that trees suffering from "die-back" should not be pruned until the onset of regular rains.

It is recommended when pruning both single and multiple-stem coffee, that only light prunings are required, except perhaps in the case of trees that have not been pruned for several years. Heavy pruning is apt to upset the balance of the tree. In single-stem trees particularly, if the tree is topped and the lower primaries always pruned severely, then they respond by producing extra leaf and lateral growth, at the expense of flower and fruit formation. Hence the need to prune carefully and as little as possible.

In the Highlands the time of pruning would appear to be one of trial and experiment for the present and may even vary slightly for different centres in the Highlands. Perhaps the best time for pruning would be after the heaviest cropping period and before the main flowering. Although this time may vary slightly throughout the Highlands, present indications are that it would be between the months of June and September.

Mulching.—

Mulching of coffee plantings in the Highlands is strongly recommended, particularly in view of the protracted dry season that may be experienced in Highlands coffee areas.

Mulching combines the functions of suppressing weed growth, maintaining a cooler soil temperature, prevention of soil erosion, addition of plant nutrients to the soil, conserving soil moisture and assisting the penetration of moisture at depth and so replenishing the subsoil reserves. Compact and eroded soils resist moisture penetration but mulching tends to renew soil structure and to create absorbent properties in the soil.

Experience in East Africa has indicated that while it is essential that there be sufficient moisture in the subsoil all the year round, it is also beneficial to the coffee plant that the topsoil be dry for part of the year. An indication of this is that alternate row mulching has been found to give better returns and healthier trees than complete mulching. In alternate row mulching each alternate row is mulched once a year and the remaining rows the following year. A repeat procedure is followed in succeeding years.

The surface roots of the coffee tree appear to favour drier conditions for part of the year to permit the nitrogen content of the surface soil to be stepped up and to slow up growth, ripen the wood and initiate flower buds. In alternate row mulching this object is achieved without allowing the soil to become fully dried out.

The coffee pulp itself is a very valuable mulch and fertilizer and should always be returned to the coffee field as it is rich in the essential plant foods, nitrogen, phosphoric acid and potash. It is suggested that the coffee pulp be placed around the base of the coffee plant. The parchment skin has some use as a mulch but no value as a fertilizer.

In the Highlands several grass species appeal as being very suitable for mulching. *Themeda gigantea* (Giant Kangaroo Grass) is excellent for mulching purposes. It is very vigorous, easy to cut and provides a large bulk of mulching material. It also does not tend to break down as quickly as some of the less vigorous grass species.

Pennisetum purpureum (Elephant Grass) introduced from Kenya is a suitable mulching grass. It is quick and vigorous in its growth habit and can be cut back several times a year. It prefers rather moist conditions for best growth and should be allowed to dry out well before being laid as it grows readily from cuttings.

Imperata sp. (Kunai) is useful for mulching, although it does break down very quickly after being cut and laid in the field.

Banana trash, where available, is a useful mulching material, as banana trash contains

a high percentage of potash which is generally considered necessary for fruit formation.

The best time to apply the mulch is during the first few months of the wet season, October to January. Then by the beginning of the dry season the subsoil has adequate moisture reserves for the dry season, with the mulch forming a retentive layer on the surface. It is estimated that approximately three acres of grassland are required to mulch one acre of coffee adequately.

Cover Cropping.—

In the light of overseas experience plus limited local experience, it would seem that cover cropping is not to be recommended in coffee plantings, particularly where the annual rainfall is below 75 to 80 inches per annum, as it then becomes very necessary to implement more rigorous moisture conservation practices. There is little reason to doubt that in the Highlands cover crops would seriously compete with the coffee plant for soil moisture during the dry season.

As a matter of interest, the following results were obtained with extensive experiments carried out in both Brazil and East Africa, designed to compare the value of cover crops, clean cultivation, mulching and non-weeding in coffee plantings. In both instances mulching gave substantially greater yields than any of the other cultural practices. In sequence clean weeding was superior to permanent cover cropping and this in turn was superior to weed growth cover.

Weed Control.—

The problem of weed control in Highland coffee plantings presents a major problem, particularly during the wet months of the year. A vigorous, luxuriant growth of fleshy annuals such as *Galsinoga parviflora* and *Bidens* sp. presents a constant weeding problem.

As mentioned previously it is positively known that weeds compete with the coffee plant for moisture and plant nutrients. Coffee is a surface feeding plant, consequently weed growth offers serious competition to the coffee tree. It is illogical to assume that weeds can benefit the crop, even when the weeds are periodically cut and mowed and left in the field. Nutrients from the weedings or mowings become available rather slowly. On the other hand when fertilizing coffee plants, the ground covering weeds will absorb the bulk of the fertilizers before the coffee plants can benefit appreciably. Fertilizing weedy plantations will benefit the weeds more than the coffee.

Some of the more selective weedicides, particularly Dalapon, have been proved very effective in controlling weed growth in the Highlands and do not appear to be injurious to the coffee plantings. However, as weedicides are rather expensive to purchase, including Dalapon, it is doubtful at this stage whether herbicide weed control would prove to be more economical than hand weeding or any other means of mechanical or manual weed control. The effectiveness of mulching in suppressing weed growth has already been emphasised.

Fertilizing.—

Observation to date indicate that fertilizing of coffee plantings in the Highlands does produce appreciably increased yields and more vigorous trees even on the best coffee soils. The most marked responses have been obtained from complete fertilizer applications. The mixture currently being used is a Shirley's mixture containing 10 per cent. nitrogen, 5 per cent. phosphoric acid and 20 per cent. potash, 10-5-20.

Departmental fertilizer trials conducted on three plantations in the Goroka area confirmed the above observations, namely, that the most pronounced growth responses were obtained from complete fertilizer separately with the exception of nitrogen, applications. The major elements used did not produce marked responses.

Where coffee trees are suffering from exhaustion and " die-back " it is evident that the application of complete fertilizer or sulphate of ammonia hastens rejuvenation of the tree. Experience in East Africa and Hawaii has demonstrated that a nitrogenous fertilizer applied shortly after the beginning of the wet season and again near the end of the wet season, has proved to be of sound economic value. In the former case the coffee tree is growing vigorously and requires ample nitrogen to support and carry the leaf growth and to mature the crop. In the latter case the tree has matured the crop

and is usually in a weakened or exhausted condition. The application of a nitrogenous fertilizer at this stage enables the tree to survive the dry season more easily and so prevent "die-back". The above nitrogenous fertilizer applications are supplied in addition to the normal complete fertilizer applications, but not at the same time. The continued application of sulphate of ammonia is liable to increase the soil acidity and so reduce the availability of minor nutrients. This danger may be averted by using substitute nitrogenous fertilizers alternately with sulphate of ammonia. Nitro-chalk, sodium nitrate and urea can be used instead of sulphate of ammonia.

The coffee tree in production is a heavy feeder on the major elements required for plant growth. Tests conducted in Brazil have shown that one ton of green coffee removes from the soil approximately—

95 lb. of nitrogen.
18 lb. of phosphorous.
101 lb. of potassium.

These figures in fertilizer equivalents are—

475 lb. of sulphate of ammonia.
90 lb. of superphosphate.
203 lb. of sulphate of potash.

The economies of fertilizer costs and current coffee prices justify rather heavy fertilizing. In the event of coffee prices becoming appreciably lower the margin between input costs and output returns may on some of the Highlands coffee soils at least, make fertilizing a doubtful economic proposition.

Irrigation.—

In the lower rainfall areas of the Highlands and in seasons when severe dry months are experienced, irrigation of coffee plantings should prove beneficial.

The amount of irrigation necessary will be determined to a degree by the nature of the soils and other moisture conserving practices, including mulching and shade intensity. Irrigation should be regarded as a means of replenishing the reserves of subsoil moisture and not the surface soil moisture.

Overseas authorities contend that if it is possible to dispense with irrigation, then it is best avoided. The time of application of the irrigation is rather important as irrigation may induce out of season flowering. However, in low or marginal rainfall areas where it is essential for the continued health of the trees, results in Brazil have shown that irrigation may give significant yield increases.

Pests and Diseases.

Fortunately for the coffee industry in the Highlands no serious insect pests or diseases of major importance have appeared to date. The main insect pests and diseases present in the Highlands and causing some damage to coffee plantings and shade species, are :

1. Coffee Stem-Girdler Weevil. (*Cryptorrynchus* sp.).
2. Defoliating Weevils. (*Oribius destructor*), (*Oribius hostis*).
3. Coffee Leaf-Roller Moth. (*Homona coffearia*).
4. Scale Insects—
   (*a*) Black Scale (*Saissetia nigra*).
   (*b*) Brown Scale (*Saissetia haemispherica*).
   (*c*) Green Scale (*Coccus viridis*), (*Pulvinaria* sp.).
5. Brown Eye Spot (*Cercospora coffeicola*).
6. *Crotalaria* Leaf Mosaic Virus.

Coffee Stem-Girdler Weevil. (Cryptorrynchus sp.).—

The small greyish-black coffee stem borer weevil is potentially the most serious coffee pest recorded to date. Damage to the coffee tree is caused by the larvae tunnelling under the bark of the main stem in a circular direction so as to completely girdle the tree. In some instances the larvae tunnels just under the bark, whilst in other cases the tunnel extends right into the heartwood of the tree. Usually the stem is attacked between ground level and the first pair of primaries, although attack may extend further up the main stem so that the tree may be girdled a number of times.

The top part of the tree immediately wilts and in some cases dies. Because also of the ringbarking, the main stem is weakened and may snap off at the point of

Damage caused by the coffee Stem-Girdler Weevil with resultant growth of suckers below the damaged area.

ringbarking. Usually the main stem below the area of attack remains quite healthy and vigorous and produces a growth of suckers as the top part of the tree wilts and often turns yellow in colour. The tree can be rejuvenated by selecting one or more of the suckers and allowing them to grow up and form the framework of the new tree. Not many trees are killed outright as a result of attack from the Stem-Girdler Weevil. However, attack does result in a serious setback in growth and consequent loss in yield.

Departmental investigations to date have indicated that a fair degree of control and prevention of attack from the Stem-Girdler Weevil may be obtained by applying 0.5 per cent. Dieldrin spray to the main stem of the coffee tree, particularly at the beginning of the life cycle when the larvae are less than two millimetres long.

Defoliating Weevils (*Oribius destructor, O. hostis*).—

These are small, black, grey-striped weevils, the adults of which cause severe shot-hole damage to the coffee leaves. Infestation by these weevils is usually greatest where areas of fences of pit-pit (*Saccharum* sp.) are near the coffee plantings.

The adult weevils are highly susceptible to 0.2 per cent. D.D.T. spray.

Coffee Leaf-Roller Moth (*Homona coffearia*)—

The adult of this moth lays its eggs on the surface of the coffee leaf and then rolls the leaf over to protect the eggs. The larvae on emergence feed on the coffee leaves. As the larvae prefer tender, young leaves, heavy infestation by this pest may cause extensive damage to the young vegetative growth of the plant.

The larvae are effectively controlled by spraying with 0.25 per cent. D.D.T. or 0.05 per cent. Dieldrin.

Scale Insects.—

Green Scale (*Coccus viridis*), (*Pulvinaria* sp.).

Brown Scale (*Saissetia haemispherica*).

Black Scale (*Saissetia nigra*).

Infestation of coffee plants by either the Green Scale or Brown Scale is not very

serious, as the scales are fairly effectively controlled by the three predatory Coccinellids (ladybirds).

Callendra sp., *Orcus* sp., *and Menochilus 6 maculatus*.— L

Black Scale rarely occurs on coffee. It is important because of its heavy infestation of *Crotalaria* and the attendant Sooty Mould formation on the coffee leaves. Although the Black Scale is parasitised by two ladybird species of the genus *Orcus*, infestation of *Crotalaria* by *Saissetia haemispherica* is steadily increasing.

Brown Eye Spot (Cercospora coffeicola).—

Attack by this fungus is typified by brown circular spots, with concentric rings, appearing on the leaves of the coffee plant. The incidence of Brown Eye Spot attack is greatest either where the coffee plants are in a weakened or debilitated condition, or where there is little or no shade. Brown Eye Spot is easily controlled by providing edequate shade and shelter and by improving the general health and vigour of the plants.

Crotalaria Leaf Mosaic Virus.—

Although not a disease of coffee the leaf mosaic virus is worthy of mention because of the increasing incidence and severity of attack on the temporary shade species, *Crotalaria anagyroides*.

The occurrence of the leaf mosaic virus is appreciably reducing the shade usefulness of *Crotalaria* as it reduces the leaf size, growth rate, life span and general vigour of the *Crotalaria* plant and renders it more susceptible to heavy infestation by Black Scale. The leaf mosaic virus is much more serious in the Goroka area than in other areas of the Highlands. In the Goroka area the expected life span and shade usefulness value of *Crotalaria* has been reduced by at least one year as a result of the heavy incidence of the leaf mosaic virus. It is suspected that a species of *Thysanoptera* or one of the aphid species may be the vector of the virus.

Harvesting.

For top quality coffee it is most important that the harvesting and processing operations of plantation management be carefully and correctly carried out. The producer, therefore, must aim for the best quality fruit that can be produced. Only carefully applied cultural practices can achieve this end. Once harvested, the quality of the bean cannot be improved by subsequent processing, although it may be reduced in quality through improper processing.

The most important point to remember with harvesting is that only full rope cherries should be picked. Immature and over-ripe coffee is of inferior quality and cannot be improved by processing. As the coffee crop does not mature and ripen at the same time in all centres of the Highlands coffee picking at one centre or other continues more or less throughout the year. There is, however, a flush period in which the bulk of the coffee crop is harvested. The flush period does appear to be during April and May. Over the three-monthly period, April-May-June, most of the Highlands coffee crop is harvested.

Yields vary considerably from one locality to another and even on different areas of the one plantation. Bourbon trees appear to be higher yielding than typica trees, and the multiple-stem trees higher yielding than single-stem trees. Although no long-term yield figures are available, authentic yields from fifteen to eighteen hundredweight per acre have been recorded. The average yield for the Highlands over a number of years is expected to be considerably lower.

Processing.

As mentioned in the remarks pertaining to harvesting, it is of paramount importance that the ripe cherry be carefully and correctly processed from the cherry to the green coffee stage. For Territory producers to command a premium price for their product, either in Australia or on the world market, it is essential that they establish a name as producers of high quality coffee. Processing more than any other phase of plantation management is responsible for the finished product, the green coffee bean.

Pulping.—

For high quality coffee it is strongly recommended that the picked cherry coffee be pulped on the day on which it is harvested, not later than twelve hours after picking if possible. Delays in pulping may

result in a slight fermentation of the cherry pulp. This in turn may result in discoloured sour beans—characteristics that are detrimental to coffee quality.

It is considered advantageous for the cherry coffee to be dumped into a well-filled receiving tank prior to pulping. This is referred to as the flotation method and allows the grower to separate dried coffee, immature coffee and over-ripe cherries, which will float, from the better quality ripe cherries which will not float. The floaters can then be processed separately.

The pulped bean will always have a percentage of cherry skins and smaller sized imperfectly pulped cherries which often contain peaberries. This material is passed on to smaller pulper which is more closely adjusted and usually referred to as a re-passer. The bean from the re-passer may contain a high percentage of peaberry. As peaberry coffee demands a higher price it is advisable to process and market the peaberries separately.

It is important also that the pulper be adjusted correctly, so that it is not too tight or some of the beans may be nicked and damaged during pulping.

Fermenting.—

There are a number of ways in which the mucilaginous layer covering the parchment skin may be removed. These include natural fermentation, chemical or mechanical demucilaging, enzyme action, and hot water demucilaging. However, as natural fermentation is the only method of mucilage removal used commercially in the Highlands, it is not intended that the alternative methods be discussed in any further detail.

Natural fermentation consists of placing the freshly pulped coffee in a fermentation vat where fungi and bacteria decompose the mucilage to a soluble material which is readily washed off with water. The fermentating vats are usually made of either timber or concrete.

It is important that a relatively large volume of pulped coffee be placed in the vat, at least two feet in depth, so that heat from the fermentation process will not be readily lost and so increase the time of fermentation. The length of time required for fermentation depends upon the prevailing temperatures. In the Highlands it may be from 36-72 hours at least. Fermentation is faster if the fermenting vat is not full of water. Most of the water should be drained away so that the pulped coffee lies in its sticky state.

Great care should be taken to ensure that the coffee is not over-fermented and that it is washed and drained of moisture as soon as fermentation is complete. This can be determined by washing a handful of beans from the fermenting vat. If the beans are no longer slippery and have a gritty feeling, then fermentation is complete. In over-fermentated coffee a sourish or vinegary odour is perceptible.

It is very important that the coffee be washed immediately with clean water as soon as fermentation is complete, otherwise improper drying may result. However, should the coffee be washed before all the mucilaginous matter is removed, then the parchment tends to become dirty and discoloured. It is still somewhat sticky and is liable to pick up a taint or a slightly different taste derived from the juices of the pulp as is continues to ferment and ultimately dries on the parchment skin, giving a liquor that is designated at " under-fermented ".

Hence the necessity for strict cleanliness in the pulping operations, careful supervision of the fermenting process and thorough washing of the coffee at the correct time. Every means should be taken to see that unripe, over-ripe or light coffee cherry is pulped separately from the good, sound ripe cherry. Pulp skin which passes through the pulper should not be allowed to flow into the fermenting tanks with the parchment.

Drying.—

As soon as fermentation is completed and the wet parchment thoroughly washed, the coffee beans are dried. This may be done either by sun-drying or in artificial hot-air driers, or a combination of both methods may be used.

Until fairly recently it was considered that the highest quality coffee could be obtained only from sun-drying. In the light of more recent experiments and experience and improved techniques, it seems that good quality coffee, as good as sun-dried, can be

obtained from a combination of both machine and sun-drying. Machine drying by rotary driers is quicker than sun-drying but care must be exercised to ensure that each batch of dried coffee is uniform and that it is neither under-dried nor over-dried.

As the coffee bean dries it changes colour to a dull dark colour, then finally to a bluish-green colour. Hence the name green coffee. As the bean dries it shrinks within the parchment shell and the silver skin loosens. The beans may be tested for hardness by biting. If they are not quite dry, they will give to the bite. If they are dry they will break when bitten hard enough. When the parchment is completely dry it may be kept in dry storage without harm, either bagged or in bulk, to await hulling. The parchment coffee should not be kept too long in warm humid climates. Also the bagged coffee should not be in direct contact with a concrete floor. It should be stored on a wooden floor, preferably a few inches above the ground. The usual loss in weight from draining to drying coffee is about 40 per cent. The final moisture content of the dried bean should be between 11-13 per cent. Beans with a high moisture content will turn an opaque white colour upon storage. Such beans are unacceptable for good quality coffee.

Sun-drying should take from six to nine days. It should be done slowly at first to avoid a bleached bean colour. It is better to have the drying area situated on high ground, where the air is dry and breezy and sunshine is plentiful. Raised drying trays are preferable to barbecues. The parchment should always be protected from showers of rain and heavy dews.

The ultimate colour of the beans depends upon thorough and even drying. If the beans are wetted or re-absorb moisture during drying, loss in colour and quality will result. The dried beans may have a spotty appearance.

With sun-drying the parchment coffee should be turned frequently so that it dries uniformly. It should not be laid more than one inch thick when placed on the drying trays. As the parchment dries the depth may be increased slightly.

In artificial drying the temperature factor is most important, particularly if the temperatures are too high. Overseas authorities maintain that the temperature should not exceed 80-85 degrees centigrade and that slow drying up to 48 hours is preferable. The usual practice is to sun-dry for several days and then complete the drying in a hot-air drier. Alternatively, the parchment may be partially sun-dried, then machine-dried, and then dried off for one day in the sun afterwards to complete the drying process. Immediately after drying, the parchment coffee should be allowed to cool down before it is bagged or stored and before it is hulled.

In the Highlands, although weather conditions will usually favour sun-drying it would seem a sound policy for growers to make provision for mechanical drying facilities, should unseasonable weather conditions prevent adequate sun-drying. Also sun-drying entirely, on a large plantation, would mean that a very large drying area would be required. Semi-dried coffee is subject to moulding and even fermentation, if the moisture content is not low enough, thus resulting in a poor quality coffee.

Hulling and Grading.—

The hulling of parchment coffee is called shelling or peeling, and is the process in which the parchment and silver skin covering the green bean are removed. There are several types and sizes of machines for these operations. The parchment and the silver skin are removed and the bean is polished, either at the same time or in a second machine working in tandem. Adjustment is necessary for different kinds of coffee, so that two machines are normally used, one for shelling and the other for polishing.

Polishing is aimed at removing all traces of the silver skin and imparting a shine to the coffee bean. A shiny surface gives the bean a more attractive appearance, though coffee is sold more on cupping and roasting qualities to-day than on appearance.

Once the coffee is hulled and polished, it is graded to size in mechanical graders. The peaberry beans are also separated from the flat beans. The coffee can then be further graded through machines designed to separate out the lighter and heavier

beans. Much the same result may be obtained by hand sorting after the mechanical grading. On the world market the size of the bean is not so important. Rather, what is required is a uniform sample of beans with a few imperfections in the sample. In the United States trade the grades range from No. 2 to No. 8. Coffee grades lower than No. 8 are not permitted into the country.

With respect to the Territory coffee production. which to date has been disposed of in Australia, grading has not been a very necessary phase of processing. The Highlands arabica coffees, because of their limited supply and good raw beans and whole roast appearance, have commanded premium prices. Australian buyers have not discriminated to any degree with the different grades of Highlands coffee. However, should world coffee prices drop appreciably and Territory production increase considerably, there may come a time when New Guinea arabica coffees will not be in such demand on the Australian market, unless they are of a consistently high quality and grade. This should point to a greater emphasis by Territory growers on correct processing techniques, and more thorough grading and sampling of the coffee bean.

Marketing.

After the coffee has been processed and graded, it is then bagged and labelled for marketing. Double bagging is recommended as a worthwhile insurance against careless handling and storage during shipment. The filled bag should not weigh more than 180 pounds. Bags should be numbered and marked clearly with the name of the plantation and the grade of the coffee. This is a trade mark and may be of considerable value to the owner if it is favourably recognized.

Territory arabica coffees to date have been sold privately or through agents, to buyers in Sydney and Melbourne. Before being purchase by the buyers, the coffee is sampled and tasted for qualities, by liquorers. The raw coffee is first examined and although its weight and evenness are taken into consideration, the colour is considered most important. Australian buyers prefer a bluish good even green colour, with no indication of brownness, which is indicative of faulty drying or humid storage. The bluish-green colour is preferred as it is reputed to be indicative of high liquoring qualities.

It is of interest to note that recently liquorers in both Australia and overseas have advised that the use of B.H.C. (benzene-hexachloride) insecticides, for example, Gammexane, in coffee plantations, is liable to result in a "bricky" flavour in the liquor of the processed bean. This may result in a downgrading of quality.

Australian importers consider that the well-processed Highlands coffee has a good raw bean and whole roast appearance. The former means that the colour is good and generally of even appearance. The good whole roast appearance indicates a very even colour in the roast, with the absence of light or pale beans. The liquor is considered fairly coloury compared with the good quality Kenya bean but is said to lack the full-body of the Kenya coffee.

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PROBLEMS AND REMEDIES IN NATIVE COPRA PRODUCTION

D. Carey.*

OF the permanent cash crops established to any extent by the Native peoples of the Territory, coconuts would be the oldest. In the early history of the Territory the coconut was a participant of the subsistence economy only. It was not until the latter part of the 19th Century when the German firm of Godeffry and Sons, with its Headquarters in Samoa, started buying coconuts instead of processed oil, that coconuts became of commercial value to the Natives of New Guinea. This was an incentive for the more enterprising to establish further stands. Plantings have been slow and, in many areas, to-day the small number of mature nuts is alarming. On the other hand where large stands are established they are not being worked to their maximum potential, although the high price which copra is bringing to-day offers a good incentive.

At this stage we can consider our most important problem in Native copra production. It is one, although of a temporary nature, that will be present for a long time and will influence the establishment, management and production of any cash crop. This is the Native attitude towards work, production and improved management.

The Native has a different understanding of work to the European and the gap between European modern economy and Native economy is extremely large. In European economy there is need for a steady cash income and to be the possessors of this our work must be continuous. Our economy forces us to improve—we are daily learning better methods of management and using improved facilities and machinery in production. These are the demands of our money economy.

In the Native society work had, and has, a social function and value and it is performed mainly to meet obvious needs, such as for a house or food. A different set of rules governs the labour; work is not continuous and any Native who is an owner of ground may, with limited work, become a producer but being a producer is not enough. The product must be such that it is of a certain standard and should be in sufficient quantity so that the returns are able to cater for more than the obvious needs.

The standard set by us is very high for the Native with his backward technology. If he wishes to participate in the modern economy and become a successful independent producer, then readjustments must be made. He must be willing to rearrange his labour output, changing spasmodic work for continuous or regulated work. Also the acceptance of new and improved methods of planting, management, etc., must be present with a sense of responsibility. Pressure was used to increase the plantings in Papua. While pressure does and will serve a purpose, it is not the answer to the problem as it does little to create a new and favourable attitude towards production.

There is no ready tangible remedy to our first problem. Until there is a greater pressure from among the Natives themselves for a higher standard of living, incomplete education, poor management, lack of interest and continuous application will always be present and be our foremost problem to be met.

It was mentioned before that many coconut groves are not being worked to their maximum potential. Even if the desire for maximum production was present, the groves could not give their best due to haphazard establishment and poor management.

The most notable faults are :—

1. Close planting distances;
2. Poor selection of seed nuts; and
3. Unsuitable planting areas.

* Agricultural Officer, Department of Agriculture, Stock and Fisheries, Administration of Papua and New Guinea.

The majority of Native growers have had the opportunity to view European plantations and see coconut spacing. Many have had the services and advice of Extension Officers; yet they still persist in planting too closely.

Let us now consider some reasons which may influence close planting in the eyes of the Native. Such factors as :—

1. Native custom;
2. Close planting as a maintenance saver;
3. Land fragmentation; and
4. Mode of establishment

are all worthwhile suspects.

The present generation is only following the planting practices of its forefathers who did not have the opportunities and services to learn better methods of establishment. Also the older generation was working with primitive tools so it is not surprising that only small areas were closely planted so as to make maximum use of the ground.

The average grower does not concern himself much with improved management such as in the establishment of beneficial ground-cover crops, e.g., *Centrosema* or *Pueraria*. He has noticed, especially in kunai grass areas, that groves planted on the 27 or 30 feet spacing require constant maintenance. He, with his close planting which may vary from 9 to 20 feet, sees that less work is required to control undergrowth. Even where groves have been marked out by Government Officers some years ago, the Natives are reverting back to their closer planting method for this reason.

Along the East Coast of New Ireland severe fragmentation of clan land has often been noted as the reason for closer planting. The owners of small scattered areas who require a certain number of nuts for subsistence, pig food and a cash income will always have a tendency to over-plant an area.

In the Islands region, it is a common practice for the Native to plant his food garden, down to nuts, directly after harvesting. As these areas are usually small he will plant too closely to save himself extra clearing work. This is most noticeable in areas where the secondary bush growth is large.

The small holder knows little about selection of his planting material and usually the most hardy nuts are the ones selected. In many cases ignorance and not laziness is responsible. In parts of New Ireland, selection is done, the biggest nuts usually being chosen. Due to the small size of the nuts in this District (6,000 to 7,000 nuts to the ton), some Natives are becoming size conscious. In many parts of the Territory I should imagine that sufficient good planting material is unavailable and this is so in most parts of New Ireland. Planting material is therefore being brought in from the Government Plantation at Baibara in Papua.

Often it has been noticed that the best areas are not always selected for planting; land distribution and ownership are avoidable factors. Many excuses are often given but the distance factor is usually the influential one. In the past the Native has been accustomed to plant in close proximity to the settlement because of defence purposes. The closest areas to a village are usually the most heavily planted irrespective of soil types and suitability.

With the planting of the nut the producer is little concerned with the size of the planting hole. He has been concerned with his subsistence gardens which require little cultivation, a digging stick being the only implement needed. He has observed that self-sown nuts mature and produce.

On the management side three notable factors adversely affecting copra production are :—

1. Irregular maintenance which results in secondary bush growth and the establishment of self-sown nuts.
2. The firing of the undergrowth in place of regular grass cutting.
3. The non-establishment of beneficial ground cover crops.

Poor establishment and bad management, besides causing a slight lowering in copra output, may even cause total loss of output. The results of such factors may be responsible for the establishment of economic insects. Where there is a high incidence of an economic insect in small, scattered, poorly attended plantings control is extremely difficult. This may be our biggest

problem with the *Axigastus campbelli* (Nut-fall bug), in the Lihir Island District where it is causing a 60 per cent. loss in Native copra production on the islands of Mali, Masahet and Mahuri.

Although coconuts have been with the Natives for some years he knows little about their requirements. In many areas to-day the small holder is improving his method of establishment by the planting in lines. Although the planting distances are still too close a step in the right direction is being made.

There is one service operating at present which is causing interest amongst the copra growers and which, if followed through, will greatly improve planting methods. This is the distribution of seed nuts forwarded from Papua. To what extent these seed nuts can improve the present method of establishment will depend on the supplying officer in each area. On the introduction of these nuts to an area I suggest that one family group be found who is prepared to clear at least one hectare. Supply the nuts and help in the making of the seed bed; this should be in a prominent place. Create a little activity on the lining of the area and diggings holes; get as much help as you can. After the planting of the nuts return to the block a few times to note the maintenance work being done. Do not be too forward in supplying other nuts to that village. If approached adopt the attitude that these nuts are special and that it is not everyone who can establish them correctly and that you are reserving them for the conscientious grower. In supplying the nuts make sure that they are established on the same lines as the first block. With further supplying of these nuts the chances are very high that future coconut plantings will be a vast improvement on the present Native establishments.

Features present to-day in a matrilineal inheritance group may have a bearing on the ease with which further establishment and expansion is being made. Prestige in the old society was based on personal ability. Such matters as the size of gardens, number of pigs owned, etc., were of importance. There was little time for the lazy members of the communities; they were present but they played no parts of importance in high village affairs. Under the old society a "Bigman" could be guaranteed that his prestige, power and name would be carried on. To-day, where the social life is changing and family ties are not as strong as before, a "Bigman" cannot be assured that his name, work, etc., will be upheld by his relations. It is therefore possible at this stage of the changeover, that he is not willing to work hard and establish a permanent crop such as coconuts, unless he is assured that his direct descendants will benefit from his efforts.

Establishment of a Second Permanent Cash Crop.

I now mention many groups of people along the East Coast of New Ireland who have a cash crop established—coconuts—not working to its maximum potential, yet are establishing another permanent cash crop—cocoa. It is not difficult to see why this should be.

Territorial cocoa to-day is sold on the worlds market at £250 per ton. Copra is sold at £70 per ton. Native people who know little about establishment, maintenance, processing and work involved will naturally decide that cocoa is the better crop.

While an agriculture based on a monoculture is dangerous, the introduction of a higher priced second permanent cash crop will cause a lowering of interest in the lower priced established crop.

There is no quick solution to overcome these establishment and management faults.

Let us now turn to the more difficult side of Native copra production, the drying of the kernel for the market. Here we are not only faced with the failings of the small holder, but must also contend with technical problems.

To date Native produced copra has a poor name on the world's markets. The forwarding of under-dried copra results in a contaminated product at its destination. Its usage to-day is limited and can only command the poorer markets. Our ultimate aim is to guide the small holder into producing a first grade copra which can be used in edible oil production; such oils having a wide variety of uses and thus will find the better markets. On the introduction of strict copra inspection by qualified

officers, under-dried and inferior copra which previously was accepted is now an unacceptable product. Continual rejections resulted in a lowering of Native copra output as many small holders stopped making copra. Whereas copra grading adversely affected the operations of the co-operative organization it paved the way for improvement in Native copra production. Previously the Native producer was supplying an under-dried, inferior copra with a minimum amount of effort and poor facilities. He was having his product accepted and receiving almost the same cash returns as other producers who were supplying a good product. It is not surprising, then, that there were only odd producers trying to improve their product and maintain a good standard by continuous work and improved drying facilities.

I would like to mention at this stage the way copra inspection created the stimulus in the improvement of Native copra in the New Ireland District. Continual rejections of the copra being produced in the Nalik area resulted in a position being reached where the Co-operative Society would have to close down due to financial embarrassment. As this area is some 60 miles from Kavieng and as there are no Native owned trucks, the small producers who are in the majority were dependent on Co-operative transport. Many of the producers ceased to make copra and sold their coconuts to Chinese traders. It did not take them long to see that with the removal of the Society they lost :—

(*a*) Transportation of their product and other trade goods; and

(*b*) The competitive purchase price which Co-operatives force.

In view of the situation, and on it being explained that their driers were inferior, they agreed to the erection of hot-air driers. The Society would then operate again for a trial period of six months. To-day, after nine months, the rejection figure is approximately 4 per cent. and the majority of the copra is being accepted at Hot-Air or F.M.S. Grade.

Odd producers from other parts of the district have seen the driers and are now requesting that such driers be erected in their respective areas. This, I feel, is the beginning of the adoption of a new attitude by the New Irelander to his copra.

Many of the present producers can remember when copra was £5 per ton. To-day he will receive for the lowest grade £59 per ton and for the highest quality copra he can produce, £62 10s. per ton. A difference of only £3 10s. exists between the price per ton for the poorest and best copra produced. There appears to be little incentive for the producer who, at this stage, is not interested in earning additional income, to improve his standard of copra. Copra rejections to-day are principally due to the forwarding of under-dried copra.

Firstly, let us consider the methods of drying in use. We have sun, smoke and hot-air drying. The first two methods have many points in favour of their use in preference to the third, in the eyes of the Native.

The sun drying method, which may vary from the splitting of the nuts and leaving them face upwards in the sun, to the erection with bush materials of simple stands with moveable roofs, is very attractive to the small holder because of the little erection work and the almost nil financial outlay. Another practice very common along the West Coast of New Ireland is the erection of stands attached to a villager's house carrying moveable trays which are pushed under the house for protection during rains and at night. Sun drying is a precarious method of drying. Constant supervision over an extended period (one week and longer), is necessary in doubtful weather and is one which is not suited to this Territory all the year round. In the sun drying Society areas in New Ireland the profits made in the dry season are only paying for the re-conditioning during the "wet". Even during the dry season a good product cannot be guaranteed due to the location of the driers in close proximity to the beach. Constant supervision during the day cannot prevent the damage that can be done to partially dried copra by the cold salt-moisture-laden winds at night. On the other hand many small holders are content to use the sun drying during the dry season with the result that they are without a suitable drier on the approach of the "wet". They then

proceed to hurriedly erect an inferior type of smoke drier to carry them over the remaining wet months. The building of such emergency driers does not lend itself to improvement in design.

The average smoke drier which is in use is easily erected and is made from bush materials with the result that little cash outlay is required. The main construction faults in these driers are—

(*a*) Drying chamber is unable to hold the heat;

(*b*) Poorly regulated ventilation; and

(*c*) The bed is too close to the fires.

The drying time, dependent on the method of firing and type of fuel may take from four days to two weeks. In my district the time is usually one week, this period being extended during the wet season, due to wet fuel, which results in a heavily smoked and stewed product. Even with good fuel and constant attention it is extremely difficult to produce good copra from the average present-day Native smoke driers. It would appear that where the method of drying requires a lengthy period, the small holder becomes lazy and careless and in the case of smoke drying this results in intermittent firing. Intermittent firing is often responsible for discolouration, decomposition by bacterial action and the growth of mould and only at the best of times be any but an inferior product.

The third method, Hot-Air Drying, is now to be considered. Previously it was mentioned that while our ultimate aim was to improve the quality of the small holder's product, our first problem to meet was the obtaining of a well dried product. As quality is largely dependent on the moisture content I feel that we can reach our goal quickest by the introduction of hot-air driers. Where the drying extends over a period from 30 to 40 hours there is a greater chance of the small holder giving continuous supervision to firing, than over an extended period as in smoke drying. With the erection of small hot-air driers, new and strange methods of construction must be used, and this, coupled with a financial outlay, makes the producer reluctant to change from his long adopted methods used in sun and smoke drying.

As the copra grade prices provide little incentive for the producer to change from smoke to hot-air drying we can only meet this reluctance half-way by the introduction of driers which are—

(*a*) Of simple design and which utilize materials easily available; and

(*b*) Of low financial cost.

I will not go into the construction details of a suitable drier except to mention the two basic elements as above. It is essential that the design be such that it can be erected by any villager. Also, as the Native does not appreciate a long, drawn-out work period programme, simplicity will enable the job to be done quickly.

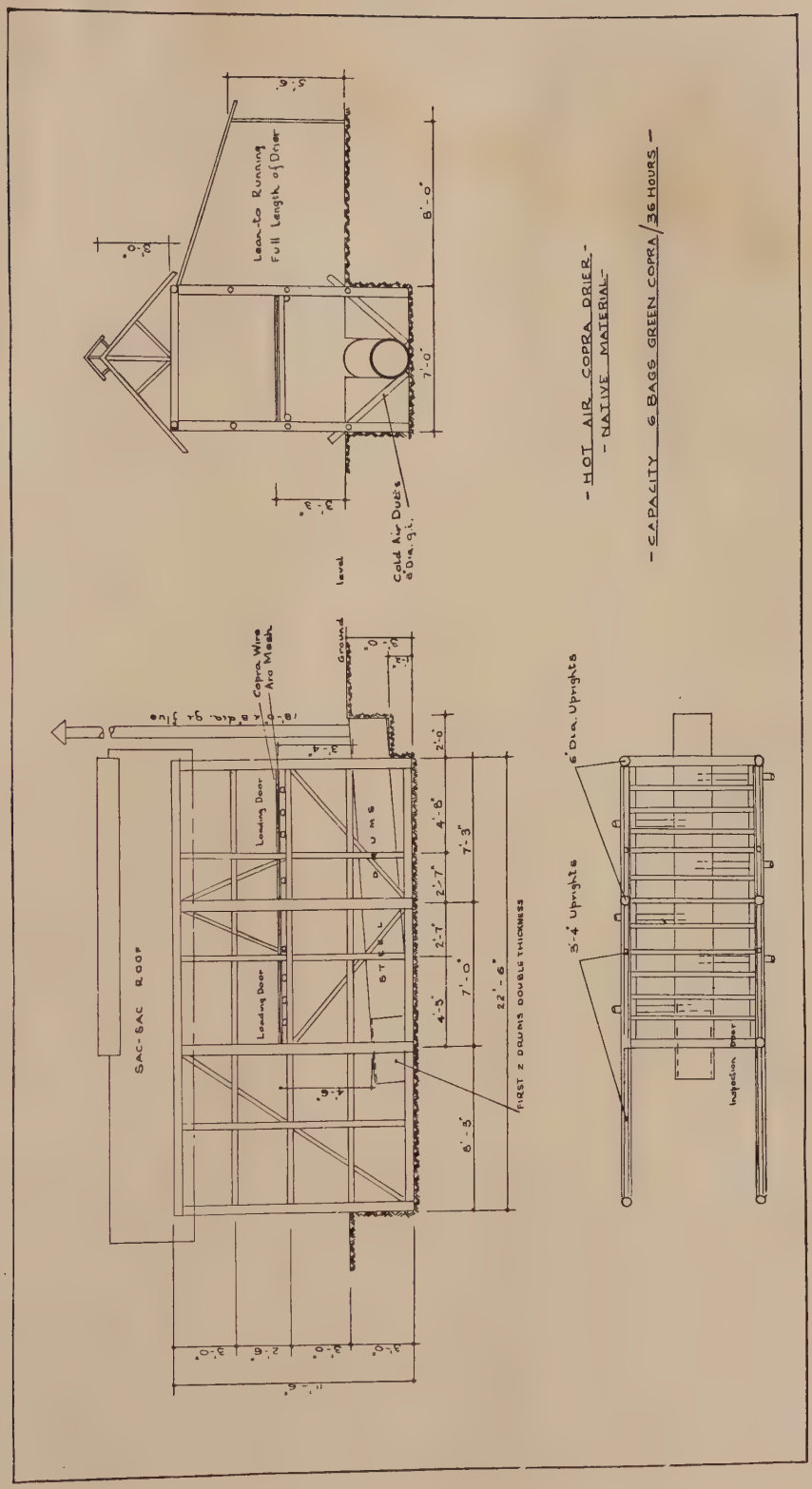
A producer who may need a drier is usually reluctant in paying out money for materials, so cheap erection costs are often the deciding factor as to whether a hot-air drier will be built. Advantage can be taken in most areas of war salvage materials. The hot-air driers, which we are erecting in New Ireland (capacity 6 bags of green copra—drying time 36 hours) are being built for £23 5s. Utmost use is made of bush materials and war salvage materials. The £23 5s. buys the necessary European materials, i.e., 44 gallon drums for the flues, flat iron for the making of the chimney and cold inlet pipes and the copra wire. This is extremely cheap, yet many producers are not willing to make the financial outlay.

In some villages where these driers have been erected they are being worked communally. Where this happens every producer, after drying his copra, must throw into the fund a nominal fee per dried bag. The money is being held in trust to buy European materials for a permanent drier at a later date. This idea was germinated by the villagers themselves and, while it may have its complications, it shows a new attitude to hot-air driers.

The present-day Native hot-air driers, while giving a dry product, supply a very variable crop copra. The major faults are—

(*a*) The bed is too close to the flue pipes which results in heavy charring; and

(*b*) Poor ventilation which may also produce charred and discoloured copra.


- HOT AIR COPRA DRIER -
- NATIVE MATERIAL -
- CAPACITY 6 BAGS GREEN COPRA/36 HOURS -
Lean-to Running Full Length of Drier
Cold Air Ducts
Level
Ground
Copra Wire Ara Mesh
Loading Door
Loading Door
SAC-SAC ROOF
FIRST 2 DRUMS DOUBLE THICKNESS
6' Dia. Uprights
3-4' Uprights
Inspection Door

After the erection of a suitable hot-air drier we must now combat the faults in harvesting and preparing the nuts for drying. Bad harvesting and preparation of the kernel may result in an unacceptable product. As this is not a technical paper on copra I will only mention the most common faults we see in the field.

1. *The Utilizing of Immature Nuts.*—

This will give copra of thin, leathery qualities of lower oil content. It can be picked out by examining the outer surface which has a shrunken and wrinkled appearance. While this copra is acceptable for the market it has been noticed that it requires a longer drying time and if bagged with other copra of the same batch it may develop moulds and contaminate the whole batch. This copra must not be mistaken for copra which has been made from nuts which have fallen prematurely, or as classified "dry" season nuts.

2. *The Utilizing of Germinated or Split Nuts.*—

Copra from germinated nuts is often rich in oil, but has developed a high free fatty acid content which is not popular with the buyers. Split nuts result in bacterial action which causes discolouration and decomposition. Also a red stain which is readily transferable to other unstained copra when bagged may result from copra which has been made from split nuts.

3. *Heavy Fragmentation of the Kernel.*—

With hot-air drying the usual way to cut the kernel is by the finger cut method. This is the partial division of the meat to be removed in the one piece. Inexperienced cutters will have a tendency to completely divide the meat thus removing it in small pieces.

Numerous small pieces result in a larger surface of the copra meat to be exposed thus enlarging the possibilities of infection. This is usually the point brought up by the people who are adverse to hot-air drying and who favour the Ceylon method of drying where the kernel is cut in the half-nut. The answer to this is that fingercut copra provides for quicker and better drying and is more suited as regards space for the average small holder's drier. In addition, less labour and attention is required; whereas the labour quantity does not particularly interest us the attention factor does.

4. *Careless Cutting.*—

Little care is taken by the small holder when splitting his nuts and the factor which is most noticeable is the presence of foreign matter, notably sand. The nut, on breaking, should not be completely severed. If so, the axe throws up sand or ground which readily adheres to the set sticky surfaces of the copra. This stays with the copra right throughout the drying period and may result, if in high percentage, in rejection.

Once the copra meat has been cut it should be placed as soon as possible into the drier. The quick sealing of the face of the meat will determine the quality of the finished product. The small holder invariably places the meat into a cold drier, even after being warned. Slow sealing results in a brown discoloured surface which is quite different from the discolouration caused from scorching.

Slow sealing allows for decomposition which results in discolouration, pitting, etc.

Good operating or attention to firing is of paramount importance in the production of a good quality product. Intermittent firing in the present-day smoke drier is responsible, in the majority of cases, of the under-dried and inferior copra which is being presented to-day. An improved hot-air drier is also useless without adequate firing and until the producer adopts another attitude towards labour, giving continuous work in place of spasmodic work, poor operating will be one of our biggest problems. The rectification of this problem is entirely in the hands of the small holder.

On the removal of hot copra from the drier we immediately meet another major problem in Native copra production. This is poor and inadequate storage. Where the storage space is limited we find the small holder bagging the copra hot, which results in the copra sweating. On the erecting of a hot-air drier a small cooling and storage shed should be erected in close proximity. It is best to erect the complete drying unit at the one time as it is extremely difficult to have the storage shed erected at a later date as the Native producer does not con-

sider it of much importance. The small producer is quite content to bag the copra hot and store it in or under his house.

When erecting a storage shed two features must be considered, location and type of building. Where Native materials are used in construction it should be well situated away from the beach front to avoid the collection of moisture from the salt spray. Where Native settlements and groves are situated along the beach front as in New Ireland this is often difficult to avoid. The site chosen should not be over low-lying ground or in close proximity to damp areas such as sago swamps. In one area on the West Coast copra was being received which was heavily red-stained. On investigation it was seen that copra, well dried, on removal from the drier, was becoming stained after a month's storage. On the removal of the storage shed from the edge of a sago swamp to a dry area the red stain disappeared.

Size of the building is, of course, dependant on the production. However, it should be large enough to act as a cooling shed as well as a drying shed. On the removal of hot copra from the drier it should be spread not heaped on the floor of the building to cool. An authoritative opinion states that copra should be left four to five days before bagging. Where we are working with Native material buildings which are situated in many cases in close proximity to the sea it would appear that two days is sufficient, otherwise too much moisture is collected by the copra.

The building should be raised from the ground and well ventilated. If in some districts Native finances are sufficient to erect a storage shed with galvanized roofing, walls and a concrete floor, an important feature to bear in mind is never to lay the bags in direct contact with the concrete. This causes the lower bags to sweat and the cement in the concrete appears to have a burning action. This results in the copra becoming rotten and putrid, and will affect other copra in the building. This can be overcome by stacking the lower bags on split coconut logs or some such material.

Good quality copra is reliant on many factors and storage is another factor which may determine whether the product is acceptable or not. Good storage conditions must be stressed as much of the Native copra is dependent on water transport for collection. Shipping is not always reliable in the Territory due to uncontrollable circumstances and copra may have to be stored for as long as six months in the Native villages. This now brings us on to water transportation where primitive transport and methods of loading present a problem, the remedy for which is difficult to see. Firstly, we have the transportation from village to village to a point of concentration. During transit rough seas, leaky canoes and careless handling result in many bags arriving wet. This wet copra is very seldom dried out by the Natives prior to storage, thus we have copra which will deteriorate quickly and adversely affect other copra of good quality in the small storage shed. Such copra under poor storage conditions becomes rancid and mouldy and readily attractive to insects. Upon the entry of insects into the storage shed other well dried copra is in danger and the foreign matter created by their activity can result in rejections. On the loading into the bigger ships, which are usually loaded by surf boat at the concentration points, the same problems exist.

We have now noted the common faults made by the small holder. The correction of these faults in some instances is not directly in our hands, e.g., water transport problems due to outside circumstances. However, other problems such as the prevention of under-dried copra and the improvement of quality is further complicated by the method of purchasing. As the majority of Native copra is purchased and marketed through the Co-operative organization we must now note the complications which arise through the *Modus Operandi* of such an organization. The focal point is the buying centre; here we have a Native clerk trained in book work only who is responsible for the purchasing of a Society's copra. He knows little about the product he is purchasing, being chosen only for his academic qualifications. While this matters little with the purchasing of a green product it becomes of paramount importance when dealing with a finished product. Where copra is purchased in small quantities, e.g., by the basket, we find various grades under-dried copra and dried copra being bagged

together under one shipment number. It needs very little under-dried copra to cause the rejection of the whole consignment. Our problem arises from the Native attitude which this method of purchasing creates. A producer who is marketing an inferior and often under-dried product is having it accepted by the Society's clerk and is receiving the same payment as another producer who is selling a better and well dried product.

This problem we must accept as the Buying Clerk is usually just another villager who will be influenced by the " pull of the village ", thus is under an obligation to purchase all copra which is brought forward.

Our only solution to this, I feel, is the standardization of driers through a Society area. If there are no influencing circumstances such as we saw in the Nalik to cause the swing over to hot-air drying, patience, good talking and hard work are the only weapons an Extension Officer can use to promote new techniques into a Native society. With the introduction of a demonstration drier to an area be on the job yourself. On completion, test the drier and personally supervise the firing. The dried product, provided the drier design is all right, should be of F.M.S. or Hot-Air standard. If possible forward to the Copra Marketing Board, this copra with a few of the Natives concerned with the drier. When they see the copra accepted as marked they will have something to talk about on the return to their village especially if rejection at an earlier date has been high. By doing this you have proved to the villagers that the drier is capable of producing a good product if properly worked. Any future unacceptable or low grade product will be entirely their own fault. This may help to develop a sense of pride in their workmanship.

Do not think that the erection of a demonstration hot-air drier in an area will result in other drier construction.

The average Territorial small holder does not learn from observation because he has never been forced by necessity; he learns only by being told what to do and how to do it. For the further continuation of future erection of driers on improved lines in an area it is necessary to organize the labour, do the ground work and, at a later date, return to check on the work. For the first few months that the driers have been in operation it is advisable to make casual revisits to the area just to check on operations. In Society areas in the Kavieng Sub-District, where hot-air driers have been constructed in every village, each village has been given a number which is marked on the bags under the Society number. This enables one to keep a check on the copra of respective villages when it is not possible to make a visit to the area. Casual enquiries and inspection of driers by patrolling officers of other departments helps considerably in holding the Native's interest in his work.

Coconuts are the oldest established permanent cash crop of the Territorial Native. We to-day are still facing problems which existed pre-war, we are still seeing the majority of the Native produced copra accepted as the lowest grade copra marketed in the Territory. We are still experimenting to find a suitable drier to introduce to the small holder. At this stage we can supply one but the question is will it be accepted in the majority of cases—no.

To quote—" While production is not up to maximum potential, nor the quality is as desired, a level has been reached where the Native producers' additional cash requirements are balanced against his unwillingness to make further efforts ".

To date the progress in the improvement of Native copra has been slow; progress must be accelerated. As a material incentive to improve is absent we must create a psychological incentive. This can be done by increased publicity and visual education. In the old Society of Native peoples of any area prestige and price was dependent on personal ability. In some areas people were renowned for their hunting ability, others for their fighting or gardening ability. To-day this sense of pride is waning and the effect is being seen in the daily work. This pride, must be rejuvenated.

As the Native is essentially of an envious or jealous nature the rejuvenation of this pride should be possible. The showing of movie films of Tolais erecting hot-air driers to a New Ireland community would help

to stimulate the activity in hot-air drier construction in New Ireland. Films of drier construction in New Ireland will stimulate the erection of hot-air driers, for example, in the Bougainville District.

We need only one Native in a strange village audience to think that he is missing out on something if he does not erect a hot-air drier, to start the erection of improved drying facilities off in a new area.

This is, I feel, the approach we must make but the facilities are not available. In conclusion, I wish to repeat that until there is an urgent need in the Native economy for a steady cash income, ignorance, poor management, lack of interest and absence of continuous application will always be present and be our foremost problem to be met.

SOME INSECTS OF BANANA IN THE TERRITORY OF PAPUA AND NEW GUINEA

J. J. H. Szent-Ivany and J. H. Barrett.*

Summary

This paper gives short notes on fourteen species of insects which are found on Banana (*Musa sapientum*) and one is recorded from *Musa textilis*. Eight of these are claimed as new economic records, three being undescribed species. All were collected within the Territory of Papua and New Guinea.

Dumbleton (1., p. 136) and Frogatt (2., p. 300) record three insects from bananas in this Territory, namely :—

I. Banana Weevil Borer (*Cosmopolites sordidus* Germ.), a tropopolitan species and regarded as "the most serious banana pest in Queensland". (5., p. 162).

II. Banana Scabmoth (*Nacoleia octasema* Meyr.), a Pyralid moth which causes extensive damage to this crop in Fiji, but is controlled to a major degree in this Territory by local parasites.

III. *Papuana laevipennis* Arrow., a Dynastid better known as the "Taro Beetle", and a major pest of this staple food of Natives of many areas. Unidentified species of *Papuana* are mentioned by Froggatt (2., p. 200) as pests of banana and he was of the opinion that in this Territory these were of more consequence than the Banana Weevil Borer.

The above are the only published records of banana pests which could be found for this Territory. This paper records various other insects which have been found associated with Banana (*Musa sapientum*) during more recent years. All are thought to represent new records.

A. *Dynastidae*.—

Both *Scapanes grossepunctatus* Sternb. and *Scapanes australis* Boisd. have been found boring into the pseudostems of banana plants. *S. grossepunctatus* (See Fig. 1), the indigenous Coconut Rhinoceros Beetle, was observed causing severe but sporadic damage in the Keravat area of New Britain by the senior author. Some banana plants on the Keravat River were severely attacked but the low infestation was probably due to the abundance of alternate host plants in the surrounding rain forest.

Fig. 1.—Scarpanes grossepunctatus Sternb. (Natural Size.)

Szent-Ivany also found *S. australis* (Fig. 2) in September, 1954, near the Mageri Agriculture School, Sogeri, Papua, at an elevation of 1,600-feet attacking isolated bananas in secondary bush adjoining monsoon forest.

Fig. 2.—Scapanes australis Boisd. (Natural Size.)

* Entomologists, Department of Agriculture, Stock and Fisheries, of the Papuan and New Guinea Administration.

S. grossepunctatus was observed by J. Richardson (July, 1955) boring into the trunk of Manila Hemp (*Musa textilis*) in the experimental blocks at Keravat.

Both *Scapanes* species attack the Coconut but the damage is not so extensive as that caused by the introduced Asiatic Rhinoceros Beetle (*Oryctes rhinoceros* L.). *Scapanes australis* is restricted to the mainland of New Guinea and *S. grossepunctatus* occurs in the Bismarck Archipelago and on Bougainville Island. The two species can be readily recognized on the size of the rimmed punctures on the elythrae. Those of the latter average 0.3 m.m. in overall diameter while those of the former average only 0.1 m.m. (See Figs. 1 and 2). This results in the elythrae of *S. australis* being much more shiny than those of the other species.

B. *Melolonthidae (Cockchafers).*—

Dermolepida nigrum Nonfrid. Adults were collected in large numbers on bananas in the Mekeo District in 1955. F. Arndt reported extensive chewing of this plant which is commonly grown in the Native gardens. *D. nigrum* (Fig. 3) varies from 25 to 30 m.m. in length and the colour varies, the elythrae being light to dark brownish black, and shiny except close to the margin. Nothing is known of the local breeding habits.

Fig. 3.—Dermolepida nigrum Nonfrid (X 1 1/4.)

C. *Curculionidae.*—

Apirocalus cornutus Pasc., a polyphagous weevil was found in large numbers defoliating bananas at Madang by Szent-Ivany (June 1956). Both young plants and the flowers of older plants were attacked. Adults are susceptible to 2.5 per cent. B.H.C. dust.

D. *Trypetidae.*—

Strumeta musae Try., the Banana Fruit-fly has been bred from the fruit from various localities during the last few months. Adults were reared from infested fruit from Samarai, collected in May 1957 (W. Cottrell-Dormer), while this species was bred from bananas at Lae (R. W. Paine, Department of Agriculture, Fiji). Material collected at Subitana, Sogeri, Papua (1,700 feet alt.), by the junior author during the same month also yielded *S. musae*. Distribution is fairly general but populations are low.

E. *Amathusiidae.*—

The banana was found to be a host of the butterfly *Taenaris myops kirschi* Stgr. at Port Moresby by G. Gitti. The rapidly feeding larvae, in clusters of up to a dozen, cause gross defoliation. Many leaves were stripped to the mid-rib. The larvae fed and pupated in the cage, the adults emerging 13 or 14 days later. The full-grown lava (Fig. 4) is two inches in length. The colour may be described as a dirty greyish yellow the dorsal surface being darker than the rest. Each segment has dorsally three longitudinal lines and two bunches of rough hairs. The colour of the head may be reddish brown or black. Dorsally on the

Fig. 4.—Taenaris myops kirschi Stgr. (Larva ; Natural Size.)

Fig. 5.—Taenaris myops kirschi Stgr. (Pupa ; Natural Size.)

Fig. 6.—Taenaris myops kirschi " Stgr. (Head of Larva ; X 4.)

Fig. 7.—Taenaris myops kirshi Stgr. Adult male upper surface. (Natural Size.)

Fig. 8.—Taenaris myops kirschi Stgr. Adult male, lower surface (Natural Size.)

head are two slightly divergent "Horns" each with a coronet of spurs, a character typical of *Taenaris* larvae (Fig. 5).

The pale green coloured pupae (Fig. 6) are about 30 m.m. long and hang by the tip of the abdomen.

The adults vary both in colouration and size. The males (Figs. 7 and 8) are generally smaller than the females (Figs. 9 and 10) and may be distinguished by the presence of the scent apparatus in the anal angle of the hind wing. There is a wide range of individual variation in the proportions of the greyish black and white in the wings and in the size of the eyespots. The eyespots of the hind wings are more definite on the lower surface of the wing.

The type locality is Aru Island (3., p. 423), but all other races are described from Papua. The subspecies *T.m. kirschi* is described from Port Moresby and is probably restricted to the Eucalypt Savannah and to the Monsoon Forest area of the Central District of Papua. *T. myops* has formed distinct races around Milne Bay and the adjacent islands off the eastern coast of Papua.

Fig. 9.—Taenaris myops kirschi Stgr. Adult female, upper surface. (Natural Size.)

The Genus *Taenaris* is divided into twenty species in the Papuan Region (3., p. 420) some being rare and others "common" and many species are divided into several geographical varieties. Besides *T. myops, T. gorge* Kirsch has been recorded from banana. It occurs in Netherlands New Guinea and in various parts of the Trust Territory. It would be of interest to know if any other Papuan species feed on *Musa* spp. As previously noted, the larvae are characteristic and the adults have the large eyespots on the lower surface of the hind wings.

Fig. 10.—Taenaris myops kirschi Stgr. Adult female, lower surface. (Natural Size.)

F. *Miridae* (Capsidae).—

A small pale green Mirid was found breeding on Bananas at the Aroa River (Hisiu Beach), about 40 miles west of Port Moresby, by the junior author, in May, 1957. Colonies of up to 40 insects in all stages of development, were found on the under sides of the younger leaves. Their feeding resulted in the development of a mildly chlorotic area on the leaf. The species was not identified at the Commonwealth Institute of Entomology, London, and will probably prove to be an undescribed species (See Fig. 11).

Fig. 11.—Miridae, Gen., Spec. (X 16.)

Fig. 12.—Derbidae, Gen., Spec. (X 10.)

G. *Tingidae* (Lace Bugs).—

A species of *Stephanitis* was also found in the same area as the Mirid. Both adults and nymphs were present on the banana leaves but Barrett reports no damage attributable to this species. This also is probably undescribed.

H. *Derbidae*.—

Also on bananas in the Aroa River area was a species (Fig. 12) of this rather unusual family in which the wings are carried in erect position. The Commonwealth Institute of Entomology was unable to identify this also and it may represent a new species. Barrett found both nymphs and adults feeding on banana leaves.

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